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STUDIES IN ECONOMICS OF APPLE ORCHARDING

I. An Apple Enterprise Study—Costs and Management

By H. C. WOODWORTH and G. F. POTTER

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DURHAM, N. H.

STUDIES IN ECONOMICS OF APPLE ORCHARDING

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and
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To be published in the following series of bulletins:

Part I. An Apple Enterprise Study—Costs and Management.
Part II. A Study of Farm Organization on 12 Fruit Farms.
Part III. A Study of Orchard Problems by Means of the Budget.
Part IV. Comparative Advantage of New Hampshire Apple Orcharding.

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An Apple Enterprise Study—Costs and Management*

By H. C. Woodworth and G. F. Potter

Apple production has been an important enterprise in southern New Hampshire for many decades. The annual total farm production for the 20-year period ending in 1908 was on the average 2,793,000 bushels and for the next 20-year period the average production was 1,268,000 bushels or less than half the total production of the earlier period. According to the Federal Census the number of bearing apple trees had been reduced from 2,034,398 in 1900 to 620,412 in 1925.

Prior to 1900, however, there were few specialized fruit farms, and the large number of apple trees and the large state production were the sum of many small farm orchards scattered along the stone walls, or clustered near the farm houses. In a state survey of commercial orchards in 1925[1] only seventeen farms were found with 500 or more trees set out prior to 1895, and only 122 farms with more than 200 trees set prior to that date.

Due to two types of difficulties many of the small farm orchards of this early period have failed to survive. New insects, pests and diseases, including the gypsy and browntail moths, made spraying necessary for the production of marketable fruit or even to save the life of the tree itself. In addition, the competition of good quality apples from better organized fruit regions made it increasingly difficult for the small local grower to find a satisfactory market. In some communities the farmers lost interest in fruit and abandoned the trees to the pests. In other sections growers met the situation with improved care of the trees, found it profitable and commenced gradually to expand their plantings into specialized apple farms. Since estimates of the commercial apple crop have been available these have shown a steady increase in New Hampshire. Good profits from the McIntosh variety have contributed to this expansion. Fruit farming on a large scale is thus a comparatively new industry; at least it is when measured

* The writers are indebted to the Bureau of Agricultural Economics for forms used on the route study, and especially to J. W. Tapp and J. B. Hutson for assistance in initiating the study.

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[1] G. F. Potter and H. A. Rollins, Commercial Apple Industry of New Hampshire. N. H. Bulletin 223, 1926.

by the long life cycle of the apple tree. In the development of these larger commercial orchards, problems dealing with pest control and culture continued to be the chief interest of the operator, and the question of the economics of orcharding received scant attention. The survey in 1925 of commercial apple orchards of New England indicated a greatly increased commercial production of apples in the near future. This, with strenuous competition from other sections, might be expected to lead to lower margins between the New England McIntosh and other apples. The need for fundamental studies of the economics of apple orcharding was obvious.

The apple sections of the United States have been located and developed by a trial and error method. We are now in the midst of abandoning the more unfavorable sites and expanding on the more favorable ones. In New Hampshire, soil, climatic and other factors appear favorable; in recent years there have been few crop failures, and production has shown no large fluctuations. However, it is important to obtain a better understanding of the economics of production to determine accurately whether growers here may be able to compete successfully with those of other sections and possibly to determine those methods by which they may best hold and expand the industry in the face of strenuous competition.

STUDY UNDERTAKEN AND PLANS

For a period of three years a detailed and intimate study has been made of twelve representative fruit farms in order to study management problems, to analyze costs of fruit production under normal conditions, to see how far the economies of modern orcharding have extended to the fruit farms of the state and to project from the study an analysis and to recommend management procedure. Ten farms were studied in 1926, twelve in 1927 and nine in 1928. A detailed map was made of each farm showing location of orchards and fields. An inventory of trees, classified as to age, variety and type (whether permanent, semi-permanent or filler), was made for each orchard.

Practically all of the fields were irregular in outline, but the trees were planted fairly regularly in squares. Hence, it was found that an accurate map could be made using cross-section paper, starting at one corner of the orchard and checking in each tree around the border, coming back to the original tree from which the start was made. If varieties were mixed without definite pattern or if there were a large number of younger replanted trees, or missing trees, each tree in the whole orchard was checked in individually.

Farms Selected

Orchards were selected for the study which were more or less representative of groups or types. It might be stated, for instance, that Orchard 7 with more than 4,000 trees is representative of the large orchards that have no other enterprise in combination, while Orchard 2 represents the smaller group of large orchards that have other enterprises in combination. Orchards 1, 4 and 5 are medium-sized orchards that have other enterprises, the first mentioned having beans and potatoes, the second, strawberries, and the third, poultry. Orchards 8

and 12 are medium-sized specialized orchards without additional cash crops. Orchards 9 and 10 are each representative of the large group of orchards operated by older men on a part-time retirement basis. Orchards 3 and 6 could hardly be called representative orchards since they have a larger proportion of non-bearing and young trees than one would normally find, and yet they are typical of the situation where moderate orchard business is in the process of considerable expansion.

The farms selected do not represent a random sample, but were picked where definite problems in management could be studied. However, it is thought that the farms as a group, while they may not be representative of apple production in general, do present a rather typical picture of the situation on commercial apple orchards of the state.

Personnel

The operators vary in personnel from older men of 65 or more who are seeking to make a living from apple production without too strenuous a physical life, to vigorous young men who are under the necessity of meeting current expenses and paying for the farm. This difference in personnel accounts to some extent for differences in farm organization. The older men are not so concerned with diversification to make use of all their time. At an age when most men have retired, they are doing the thing they like to do, and if they find whole weeks with no orchard work, they are well able to use the time for personal satisfaction. On the other hand, on farms where younger men are building up a business and seeking continuous profitable employment for themselves and their employees, diversification plays a larger role.

Orchards

The twelve farms collectively had 19,132 trees in 1927. The individual orchards varied from 503 to 4,315 trees (Table 3). Thirty-five per cent. of the trees were under 10 years of age, 51 per cent. between 10 and 19 years, and 14 per cent. 20 years or over. This distribution by ages is typical of the larger fruit farms, but shows a larger percentage of trees in the 10 to 19 year old group than in the case of all commercial orchards as reported in the 1925 survey, which had only 24 per cent. in this age group. The chief difference is that the twelve farms have expanded more in the last 20 years. They are carrying a larger percentage of young trees and are doing a better job of it than the average.

The present orchard in nearly every case developed by setting new plantings around the old small farm orchard as a nucleus. The usual story is that the planting was done because the old trees were paying better than dairying. In several instances the expansion was gradual, a hundred or so trees set out each year, but in two instances large blocks were set at one time.

Of the bearing trees 42 per cent. were Baldwin, 23 per cent. McIntosh, 12 per cent. Wealthy, 5 per cent. Wagner, 4 per cent. Gravenstein and 14 per cent. other. The trees more than 30 years old were mostly Baldwin, and the newer plantings had a larger percentage of McIntosh.

Planting distances varied somewhat, but most of the plantings ten to twenty years old were set out 20 x 20, or about 108 trees to the acre. This was done with the expectation of taking out 54 trees at 18 to 20 years (fillers) and 27 more trees at 25 years (semi-permanent trees) leaving 27 permanent trees per acre. Some of the more recent plantings were made on the quincunx system with 54 trees to the acre, half of which would be cut out at 25 years. One block had been set 30 x 30.

The bearing orchards were mostly in sod mulch, and in general there seemed no difficulty in securing vigorous tree growth by that system. With well distributed rainfall and low evaporation, the system seems practical and in at least three orchards the land was rocky and rough enough to make cultivation impractical. While most of the sites were developed from former tillage fields, on two of the farms old pasture land and brush land had been redeemed for the orchard.

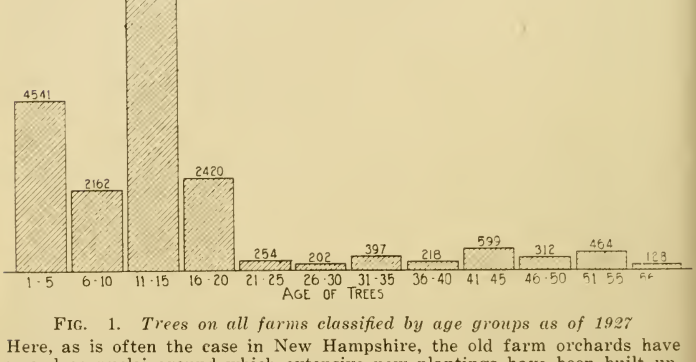

Fig. 1. *Trees on all farms classified by age groups as of 1927*
Here, as is often the case in New Hampshire, the old farm orchards have served as nuclei around which extensive new plantings have been built up. These twelve men have a slightly higher proportion of young trees than the average New Hampshire orchardist.

UNITS OF MEASUREMENT FOR COMPARING SIZE OF ORCHARDS

Studies of fruit production have usually assumed two stages; growing the trees and then producing the fruit. The costs and management problems are thus considered up to the tenth year as related to tree production, and the problems after that as related to fruit production.

Yet it has seemed to the authors of this study that the biological life cycle of the apple tree cannot be ignored. The tree is set out and carefully nurtured for several years; it begins to bear, lightly at first but gradually increasing up to full bearing and then gradually declining in yield. At what stage in this biological process can the tree be considered as grown?

A machine may be made and when made is ready for production, but an apple tree passes gradually through the phases of its life and at every phase has a different relation to the problem of cost and management. It is to be noted that with the non-bearing tree all the expense of pruning, fertilizing and spraying, etc., is an investment. A little later when the tree begins to bear, the greater part of the cost is still for investment and maintenance of trees that are expected to yield greater returns later. Even when the tree is in its prime, and while we may consider for practical purposes that all the cost is for the current crop, still the orchardist is under the necessity of doing certain things to maintain his investment. For instance, if any part of the orchard does not bear any one year, the operator with future yields in mind continues work on the orchard with some adjustments. A study of the costs and management problems of fruit production, then, is a problem involving the whole life cycle of the tree. Production of the tree and production of apples cannot be logically divorced. Important problems are missed entirely when the tree is considered as produced at a given age.

Comparison or study of operations on individual farms is most difficult on account of finding a common measure or unit of orchard. Any comparison on the basis of total number of trees would be inaccurate because the age of various orchards varies greatly. The tree of forty years has more foliage, requires more material and more work in pruning, spraying, fertilizing and harvesting than the fifteen-year old tree, and of course, should yield more fruit.

The acre unit has been employed in other regions, and no doubt is very satisfactory for comparison in standardized orchard regions, especially in the irrigated regions where plantings are uniform and of about the same age; but in New England, it would lead to erroneous conclusions. The number and age of trees per acre varies greatly. Some orchards have been set with 108 or more, others with 54 and some with 27. With relatively cheap land we need to get away from acre standards and comparisons.

In some instances, comparison has been made by the unit of crop produced; but in dealing with a long-time crop, like apples, when yields fluctuate greatly from year to year, this method is also inadequate. The costs of spraying, pruning, and fertilization are about the same whether fruit is set or not. The yield indicates something of the situation for that year, but has little value in making comparison of labor efficiency.

In order to compare different orchards more accurately two new units of measurement were computed and are used in this study in addition to the unit of actual yield. These units are: (1) "expected normal yield," and (2) "mature tree equivalent" or "mature tree unit." Operations in each orchard were corrected to these terms for comparison.[1]

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[1]When computed on a basis of normal expected yield or actual yield in the first part of this bulletin, no consideration is given to appreciation or depreciation of value of trees.

Expected Normal Yield

The expected normal yield is taken from a smoothed-out curve for yield covering the entire life cycle of the tree. There are, perhaps, too few data upon which to base such a curve. Those obtained in this study proved not to be satisfactory owing to the fact that in practically all blocks trees were of mixed ages; and even where this was not the case, the growers in the rush of harvest were not able to keep separate records on the yield from different orchards. From various experimental orchards in New Hampshire in which accurate data on yield had been kept for from 10 to 20 years, it appeared that on the average an annual yield of six packed boxes from a mature tree 35 to 40 years of age is about all that can ordinarily be expected. This checks reasonably well with data from surveys conducted in other orchard sections in the eastern part of the United States. Thus, the results of the survey in New York[1] suggest an average of about six

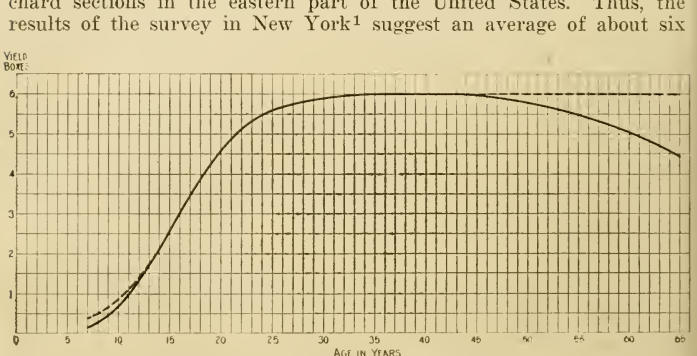


FIG. 2. *Expected normal yield*

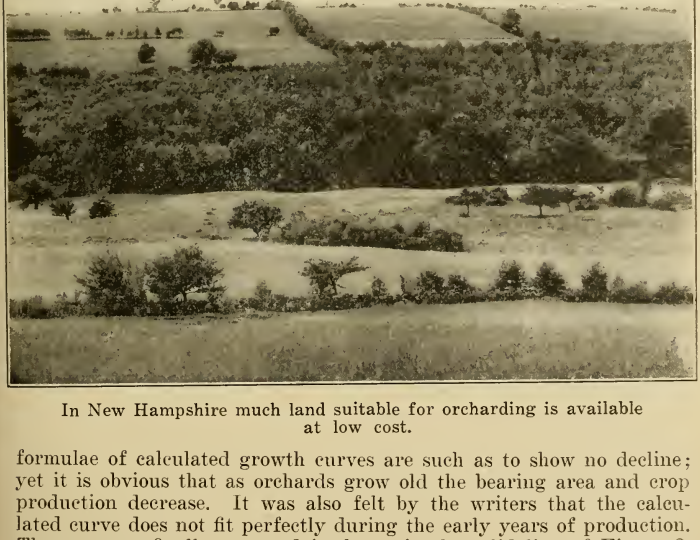
This indicates the number of packed boxes that the average orchardist growing chiefly Baldwin and McIntosh under usual conditions in southern New Hampshire may hope to harvest at each age throughout the life cycle of the tree. A curve calculated by a modification of Reed and Holland's formula for growth rate in plants was fitted to the available data on yield at different ages (dotted line). Empirical deviations from the calculated curve as shown in the solid line seemed necessary. According to this curve, the orchards included in this study should have produced 105,000 boxes during the 3-year period. Actually 115,000 boxes were marketed. Since comparatively few bearing trees more than 20 years of age are included in the study, this comparison is mainly a check on the production of young trees.

bushels per mature tree. The average yield on 441 orchards in the Cumberland-Shenandoah region[2] was 1.2 barrels per tree, and since many of the trees were not mature it seems likely that the average yield of full grown trees would be about six bushels per year.

[1] G. P. Scoville and T. E. LaMont. Apple varieties: Prices, yields, and acreages. Cornell Agr. Exp. Sta. Bull. 495. 1929.

[2] C. R. Swinson et. al. Factors influencing the yield of apples in the Cumberland-Shenandoah region. . . . U. S. D. A. Tech. Bull. 54. 1927.

The curve shows beginning of bearing at 7 to 10 years, depending upon the variety—a fact which is established beyond doubt. The writers also feel certain that a tree will grow in capacity to bear at rates corresponding rather closely with changes in growth rates as observed with various plants and as described by Robertson.[1] Accordingly, a free-hand curve was drawn showing production to begin at the seventh year and reaching a maximum of six packed boxes per year at maturity, corresponding at intermediate points to the writers' judgment and to a few data on actual yield which were available. An approximate mathematical formula for this curve was then derived, using a modification of the formulae of Reed and Holland.[2] The



In New Hampshire much land suitable for orcharding is available at low cost.

formulae of calculated growth curves are such as to show no decline; yet it is obvious that as orchards grow old the bearing area and crop production decrease. It was also felt by the writers that the calculated curve does not fit perfectly during the early years of production. The curve as finally accepted is shown in the solid line of Figure 2, the calculated curve being shown in a dotted line. Throughout most of the bearing period, the accepted empirical curve corresponds exactly to the calculated curve.

Different varieties bear differently, the McIntosh and Wealthy produce good crops at an early age, while the Baldwin and Spy mature later. It would have been more accurate to draw yield curves for

[1]T. B. Robertson. The chemical basis of growth and senesence. 389 pp. Philadelphia and London 1923.

[2]H. S. Reed and R. H. Holland. The growth rate of an annual plant, Helianthus. Proc. Nat. Acad. Sci. 5: 135-144. 1919.

the different varieties, but in view of the paucity of accurate data this was deemed inadvisable. The yields as shown in Table 1 and Figure 2 represent the authors' opinion of what an orchardist may conservatively expect when operating on a large scale in this section with a high percentage of McIntosh and Baldwin apples. In other words, they represent what would be expected with an average site by men of usual orchard experience and ability. Men with good sites and much ability should do better. In fact, the writers have several accurate records showing much higher yields throughout the early years of production. However, men with poor sites or little ability can expect less.

When the yield curves had been drawn, the number of trees of each age in each orchard was multiplied by the expected yield for that age. The sum of these gave the normal expected yield for the whole orchard. For the three years of the study the total normal expected yield for all of the orchards was 105,266 packed boxes. Actually the growers marketed 115,966 boxes. The yield curve as drawn must, therefore, be fairly accurate, at least for those age groups of which these orchards are largely comprised. It is somewhat conservative as the writers desire that it should be. After considering the relation of these three years to a ten-year average yield from the crop reporting data, we have concluded that the actual average yields in the state for these three years were about normal. With better arrangement of varieties for pollination, more attention to drainage in certain orchards and with other improvements in culture, the average yield will undoubtedly increase, but the future of this is so uncertain that it is thought best to hold the estimates to a conservative basis.

A glance at Table 2 will indicate that the normal expected yield changed considerably from year to year, due to change in age of the trees which comprised the tree inventory and also due to the removal of fillers or semi-permanents on some farms. Thus, Farm 7 had an expected normal yield in 1926 of 7,931 boxes, but two years later this expected yield had increased to 10,920 boxes. Most of the trees were young and increasing in bearing ability very rapidly. Many orchardists fail to realize this trend and are somewhat confused to know what a normal crop from their orchards should be. It is hoped that this projection of the expected normal yield will be of considerable value in giving orchard operators a standard for comparison.

A study of Table 2 indicates that the orchardists experienced wide fluctuations from the normal. In 1927 Farms 8 and 9 had yields two and one-half times the expected. For the whole three-year period three farms had yields approximately as expected, five had yields greater, and four had yields less.

Mature Tree Unit

It has previously been noted that with young trees a greater proportion of the cost of management represents investment for future bearing area than with older trees. In the early years of the orchard the operations of pruning, spraying, etc., are more nearly in proportion to the size of the tree than to expected yield. Consequently, the

TABLE 1—*Normal expected yield and mature tree equivalent at each age during the life cycle of the apple tree.*

Age	Normal* Expected Yield	Mature† Tree Equivalent	Age	Normal* Expected Yield	Mature† Tree Equivalent
1		.01	34	5.98	.953
2		.023	35	5.99	.963
3		.038	36	6.00	.972
4		.057	37	6.00	.978
5		.08	38	6.00	.983
6		.104	39	6.00	.988
7	.14	.125	40	6.00	.992
8	.26	.15	41	6.00	.995
9	.44	.178	42	6.00	.997
10	.66	.208	43	6.00	1.0
11	.95	.242	44	5.98	1.0
12	1.30	.275	45	5.96	1.0
13	1.70	.31	46	5.94	1.0
14	2.14	.347	47	5.91	.998
15	2.56	.383	48	5.86	.998
16	3.00	.423	49	5.82	.997
17	3.45	.46	50	5.77	.997
18	3.87	.50	51	5.72	.993
19	4.26	.542	52	5.66	.988
20	4.60	.584	53	5.60	.983
21	4.90	.624	54	5.54	.975
22	5.16	.664	55	5.47	.967
23	5.34	.70	56	5.41	.958
24	5.50	.734	57	5.34	.947
25	5.62	.767	58	5.25	.933
26	5.70	.80	59	5.15	.922
27	5.76	.83	60	5.06	.908
28	5.82	.857	61	4.96	.893
29	5.86	.877	62	4.86	.88
30	5.91	.90	63	4.72	.86
31	5.94	.915	64	4.60	.842
32	5.96	.93	65	4.45	.825
33	5.97	.943			

*Normal expected yield is the number of packed boxes of marketable fruit which can be expected by an average orchardist on an average site.

†Mature tree equivalent refers to size of trees at different ages in terms of a mature bearing tree at its prime.

normal expected yield is satisfactory as a unit of comparison only in orchards within a limited range in age; and the second unit "mature tree equivalent" was calculated, representing the comparative size or total foliage at different ages, expressed on the basis of the size and amount of foliage of a mature tree in its prime. One thousand mature tree units would constitute an orchard of approximately forty acres, trees set about 40 feet apart and all in their prime.

Since there were no available data for comparison of size by ages, 380 trees of varying but known ages were measured on several different farms. From these measurements, the area of the outer surface of the tree was calculated for each of the trees from the formula

for securing the surface area of a cone.[1] These data were then plotted on a scatter diagram by ages and sizes. Again a curve was fitted by the use of the modified Reed and Holland formula; for it was thought that the growth of the apple tree would closely follow the law of growth as determined for other types of plants. This growth

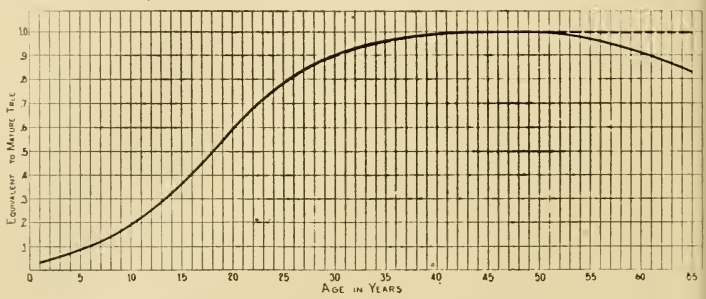


FIG. 3. *Mature tree equivalent or mature tree unit*

The actual size of trees of different ages as compared to a mature tree in its prime is indicated. This curve was obtained by fitting a growth curve to measurements of trees of different ages. The calculated curve (dotted line) was used except for old trees, some of which die and some of which lose branches resulting in a decline in average size (solid line).

TABLE 2—*Actual and expected normal yield on each orchard for three years.*

	Boxes of Marketable Apples							
Farm	1926		1927		1928		Total for 3 years	
	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected
1	3,684	3,592	3,775	4,085	4,914	4,557	12,373	12,234
2	10,400	5,367	6,217	5,901	10,800	6,364	27,417	17,632
3	1,257	2,125	2,251	2,393	3,330	2,698	6,838	7,216
4	3,000	2,416	4,092	2,756	3,645	3,119	10,737	8,291
5	2,537	2,135	4,091	2,378	3,815	2,641	10,443	7,154
6	1,872	2,966	2,283	3,002			4,155	5,968
7	7,535	7,931	10,376	9,379	6,361	10,920	24,272	28,230
8	1,903	1,778	5,362	2,084			7,265	3,862
9	933	698	2,317	863			3,250	1,561
10	623	1,276	1,407	1,340	688	1,393	2,718	4,009
11			1,200	2,357	1,200	2,592	2,400	4,949
12			1,700	2,016	2,428	2,144	4,128	4,160
Total	33,744	30,284	45,071	38,554	37,181	36,428	115,996	105,266

[1]The area of the outer surface of the cone seems to be a better measure of comparative size than the volume because in old trees the center contains little or no fruiting wood.

curve (Figure 3) was accepted as the best available representation of amount of foliage at various ages, and when made to a scale of the mature tree as unity, a factor representing the per cent. of mature tree represented by each age was available. As in the case of the expected normal yield, the number of trees of each age in each orchard was multiplied by the factor for that age, and the sum of these made the equivalent of mature trees for that farm. Table 3 shows the number of actual trees and of mature-tree equivalents for the various

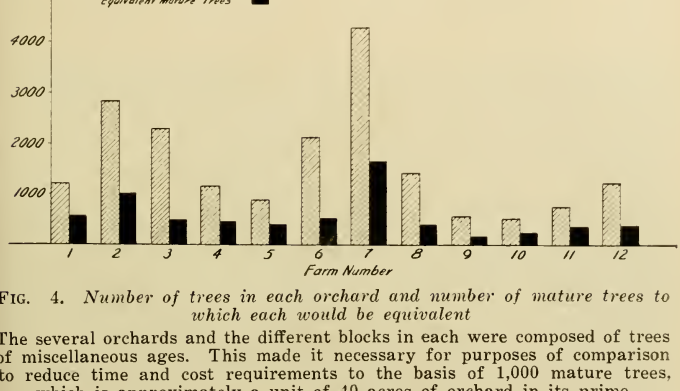


FIG. 4. *Number of trees in each orchard and number of mature trees to which each would be equivalent*

The several orchards and the different blocks in each were composed of trees of miscellaneous ages. This made it necessary for purposes of comparison to reduce time and cost requirements to the basis of 1,000 mature trees, which is approximately a unit of 40 acres of orchard in its prime.

TABLE 3—*Actual number of trees and estimated equivalent mature trees on each orchard for each year.*

Farm	1926		1927		1928	
	Actual Number	Equivalent Mature Trees	Actual Number	Equivalent Mature Trees	Actual Number	Equivalent Mature Trees
1	1,191	503	1,191	550	1,191	597
2	2,798	932	2,835	991	2,757	1,036
3	1,871	429	2,275	472	2,279	521
4	1,109	419	1,134	453	1,152	490
5	866	369	876	392	882	416
6	2,115	477	2,115	513		
7	4,315	1,489	4,315	1,625	4,319	1,758
8	1,036	359	1,396	392		
9	543	141	553	159		
10	438	211	503	220	552	229
11			724	344	724	367
12			1,215	364	1,640	392
Total	16,282	5,329	19,132	6,475	15,496	5,806

farms. It is to be noted that in 1927 the 19,132 trees were equivalent to only 6,475 mature trees. Also that Farms 1 and 12 in 1927 have about the same number of trees, but that when reduced to mature tree units, No. 1 has 550 to No. 12's 364. In comparing orchards from the view point of efficiency, this seems the most logical unit.

In most cases, each operation up to harvest was calculated on the basis of hours per mature tree equivalent, hours per expected normal yield, and hours per actual yield. While none of these measurements is perfect, the combination of all may give a good picture of the situation. Where orchards are of about the same bearing age, expected normal yield is probably the best measure in any one year. The actual yield is perhaps the best measure when orchards are of

Spray management is the chief factor in determining best unit of size of orchard. If one can spray an orchard thoroughly, the other operations up to harvest can be done without too heavy a draft upon available labor.

similar ages if the data cover a long enough period to warrant acceptance as average yields. The mature tree equivalent is best where orchards vary in age, especially if some have a large proportion of young trees.

LABOR REQUIREMENTS ON OPERATIONS UP TO HARVEST

Operations in producing apples may roughly be divided into three parts for study:—

1. Production up to harvest.
2. Harvesting apples.
3. Grading, packing, storing and marketing.

With the exception of propping and thinning, which are practiced in some orchards, the operations up to harvest must usually be done about the same whether there is a large or a small crop. Up to this point, it is possible to compare operations between farms fairly accurately, on the basis of mature tree equivalent or expected normal yield. Then, too, the problem of budgeting the orchard through a 60-year period is much simplified by carrying costs to the harvest period and allowing income on the tree.

The problem of harvest of apples varies with the yield to a large extent and can best be handled separately. The grading, packing, storage and marketing of apples could be studied only on a few farms, and it was difficult to make comparison on account of lack of uniformity of services performed.

The studies of orchard organization and management are interrelated. One might assume a given orchard and then study the best management plans in producing fruit, but a close study of the labor requirements and the inauguration of possible improvements of efficiency will soon disclose that efficiency may require a different size of orchard.

We have attempted to study the labor requirements on the twelve farms to determine how individual men are carrying on orchard operations, to compare methods and time requirements with the objective of determining the best and most economic practices, and then lastly to sum up the situation as to the most economical size of orchard.

For this purpose the operations have been arranged into two classes: (1) those requiring special orchard training and skill and (2) those which can be performed by unskilled labor if supervised by a trained orchardist. The operations have been classified as follows:—

I. Special orchard skill required.
   - a. pruning
   - b. spraying

II. No special orchard skill required.
   - (1) Early spring work
     - a. brush hauling
     - b. brush disposal
   - (2) Operations in summer to control moisture.
     - a. cultivation
     - b. mowing
     - c. mulching
   - (3) Operations when heavy set of fruit is had.
     - a. propping
     - b. thinning
   - (4) Miscellaneous.

The division of labor requirements into skilled and unskilled is important in considering economic size of orchard, because skilled men cannot be had ordinarily on short notice for short jobs, while there has never been much difficulty in getting day help for unskilled jobs. Hence the problem of balancing the business to make the best use of the skilled help is most important.

Before proceeding to study the individual operations, it may be best to get a picture of the relative importance of each by studying Table 4. The time requirements for the different operations vary greatly on the several farms. For the average of all farms, pruning took about 26 per cent. of the man hours and spraying about 18 per cent. These two operations, therefore, not only require skilled help but represent together about 44 per cent. of the total requirements. Soil management by cultivating, mowing and mulching represents about

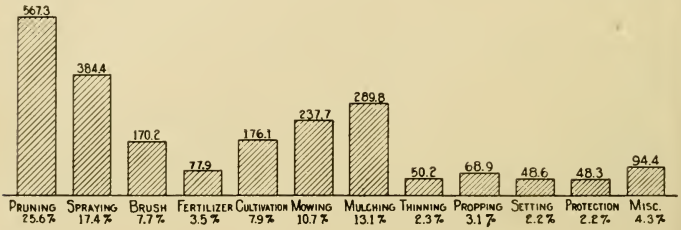


Fig. 5. *The average number of hours spent in each orchard operation and the percentage of total time required for 1,000 mature trees*

21 per cent. of the time required prior to harvest. Thinning and propping used about 15 per cent. of the man hours. The other operations were all of minor importance as far as labor requirement is concerned. The operations of pruning, spraying, soil management, thinning and propping account for about 80 per cent. of the man hours prior to harvest and should be stressed in studying labor cost.

PRUNING

In studying pruning from an economic viewpoint it is essential to have in mind the purpose or expected benefits. With the young tree, pruning is done almost exclusively to develop a strong framework. The stronger tree is obtained at the expense not only of the labor involved but also of a delay in growth and in crop production which has been demonstrated by numerous experiments.

It is to be noted, however, that an individual mature tree may at times carry 30 or more boxes of apples—a weight of twelve to fifteen hundred pounds—on the ends of the branches. The tree with weak framework or bad crotches will from time to time lose branches, ultimately lowering the yields and making the orchard unproductive as it grows older. The labor and other costs of obtaining a strong tree without weak crotches is thus justified.

TABLE 4—*Per cent. of man labor on different operations prior to harvest on twelve farms.*

	Farm Number												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
	%	%	%	%	%	%	%	%	%	%	%	%	%
Pruning	17.4	34.9	21.9	12.8	24.3	18.0	32.9	7.8	21.3	34.4	62.6	23.1	25.6
Spraying	18.1	18.0	16.6	17.4	17.5	9.6	17.6	14.9	28.2	18.0	26.2	14.8	17.4
Brush disposal	5.6	10.4	8.5	9.4	13.1	4.3	6.3	1.9	3.5	4.8	1.6	3.3	7.7
Fertilizing	1.5	2.9	5.4	2.8	4.5	3.3	4.7	5.6	4.8	11.0	5.3	2.4	3.5
Cultivation	8.5	11.0	14.2	21.2	.2	.5	1.1						7.9
Mowing	4.7	5.5	4.9	14.5	18.0	1.6	12.8	34.3	18.0	12.9	3.3	27.0	10.8
Mulching	1.7	.6	5.6	2.7	.5	5.3	1.6	.6		.3		6.7	2.3
Thinning	30.5	6.5	2.7	3.7	19.8	17.7	17.4	24.7	20.6	18.2		10.9	13.1
Propping	7.1	4.2	.1	4.6	.1	.3	.9					5.0	3.1
Setting	.9	.3	10.6	1.8	.9	2.5	.7	3.1	2.5			5.8	2.2
Protection	3.7	1.7	7.7	.1	.1	7.4	1.4					.3	2.2
Miscellaneous	.3	4.0	1.8	9.0	1.0	29.5	2.6	7.1	1.1	.4	1.0	.7	4.2
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

With the mature tree the value of pruning is more largely a subject of controversy than with the young tree. It would be expected, since pruning results in more vigorous growth of shoots and fruit spurs, that even although it may reduce the bearing area it might not lower the productivity of the tree or might in some circumstances even increase it. There is, however, but meager data to support this point of view; and in some experiments, notably those conducted in Michigan, the pruning of mature trees seems to have resulted in a financial loss by reduction of yield.[1]

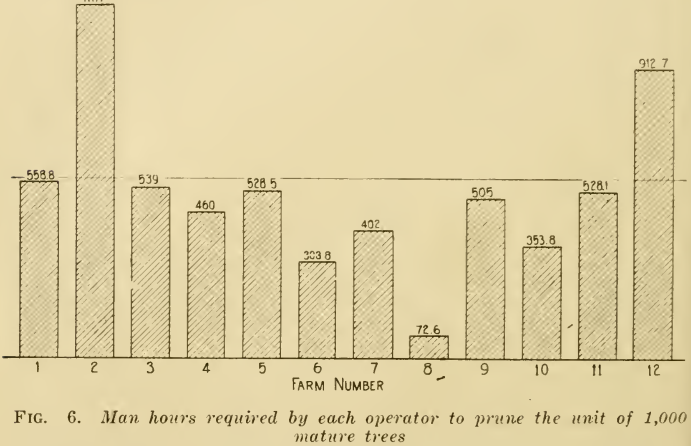


Fig. 6. *Man hours required by each operator to prune the unit of 1,000 mature trees*

Opinions vary as to type and amount of pruning necessary. Within these rather limited observations, quantity and quality of fruit was not materially improved by spending the maximum time on this operation. Detailed pruning although desirable from the point of view of the plant physiologist does not appear to result in definitely better returns.

Pruning is more or less of a thinning operation, and apples from pruned trees will undoubtedly be larger than those from trees not pruned. Whether the reduction in total crop will be so serious as to offset this benefit may depend upon the local market situation which affects the value on the tree of apples of different sizes and grades. If under some circumstances the pruned and unpruned trees were to bear the same number of bushels of good-sized fruit, which in the case of the unpruned tree is mixed with a large proportion of undersized apples, the cost of separating the latter out might be greater than the actual value on the tree of the extra quantity of small apples.

The value of certain operations in pruning mature trees cannot be questioned. Branches which bear small apples exclusively can often

[1]Roy E. Marshall—Profit and loss in pruning mature apple trees. Michigan Special Bulletin 169, 1928.

TABLE 5—*Total man hours used in pruning the 12 orchards by years, man hours per 1,000 mature trees equivalent, man hours per 1,000 bushels normal expected yield and man hours per 1,000 bushels actual yield.*

Farm Number	Man Hours									
	Total				Per 1,000 mature tree equivalent				Per 1,000 bushels normal expected yield	Per 1,000 bu. actual yield
	1926	1927	1928	Average	1926	1927	1928	Average	Average	Average
1	265.5	153.5	498.0	305.7	527.8	279.1	834.2	555.8	75.0	74.1
2	849.0	1,252.7	1,186.0	1,095.9	910.9	1,264.2	1,144.7	1,111.1	186.5	119.9
3	304.0	132.5	330.0	255.5	708.6	280.7	633.4	539.0	106.3	112.1
4	216.0	299.5	111.0	208.8	515.5	661.1	226.5	460.0	75.6	58.3
5	247.5	233.0	141.5	207.3	670.7	594.4	340.1	528.5	86.8	59.6
6	184.5	121.3	*	152.7	386.8	236.4	*	308.8	51.3	73.6
7	259.5	964.0	735.0	652.8	174.3	592.6	418.1	402.0	69.3	80.7
8	54.5	†	*	27.7	151.8	†	*	72.6	14.1	7.5
9	42.5	109.0	*	75.7	301.4	685.5	*	505.0	97.0	46.6
10	103.0	81.0	49.5	77.8	488.1	368.2	216.2	353.8	58.2	85.9
11	*	90.0	285.5	187.7	*	261.6	777.9	528.1	75.9	156.4
12	*	291.5	398.5	345.0	*	801.1	1,016.6	912.7	165.9	167.2
Total	2,526.0	3,728.0	3,735.0							
Average					474.0	575.8	643.3	567.3	94.9	86.1

*No record, not in study for year specified.

†Ill at pruning time.

be detected by the weak "scrubby" character of the twig and spur growth. They are liabilities which are best removed even if there is no new growth to take their places. Trees properly pruned remain smaller and decidedly lower than unpruned trees. This makes for more effective and easier spraying. In view of the fact that diseases like scab, persisting on high branches, may be washed down by the rain to parts of the tree below, this is of considerable importance. Then, too, the labor of picking apples on the tops of high trees is excessive, especially when the crop is light. Long ladders must be placed for a very few apples. On the whole, the medium-sized tree that results from pruning is more satisfactory than a larger tree that might result if no pruning were done. Pruning by opening the tree makes it possible for light to penetrate, and hence presumably will benefit the color of the crop. Certainly the more open branches can be more readily penetrated by the fog of spray thrown from modern spraying equipment.

Many factors may affect the time required to prune; for example, previous treatment of the orchard and the amount of fertilizer applied. Speed in pruning is attained through experience which leads to quick decisions as to where to cut. The operator who hestitates is inevitably slow. Speed might result from removing few large branches rather than a considerable number of small ones. Most horticulturists believe, however, that the invigorating effect of pruning is better distributed to all parts of the bearing area by the latter method.

It is evident, therefore, that it is difficult to compare pruning efficiency on different farms. The problem is far deeper than mere hours per tree. Yet there is need to balance all the factors involved and to determine from an economic viewpoint the amount of time which the orchardist can afford to spend on this operation.

The data shown here as hours per mature tree indicate the time used in pruning divided by the mature tree units. It is to be noted that in some instances certain trees may not have been pruned every season. It is also certain that the average time required, about 36 minutes per mature tree, is not sufficient to carry out annually the pruning operation as it would be taught in most agricultural colleges. Yet, the orchards on the whole seem to be in as good condition as when the study began. There is considerable question whether pruning of mature trees to an ideal which may have become fixed in a certain operator's mind actually results in economic gain.

Pruning accounted for about 26 per cent. of the total of all man labor up to harvest (Table 4); but on individual farms the time on pruning varied from 15 to 63 per cent. The hours of man labor per 1,000 trees put on pruning in individual orchards indicate little uniformity between farms or between the different years on the same farm.

As shown in Table 5, Orchard 2 had a high amount of labor per 1,000 mature tree units for all three years—911, 1,264, 1,145 respectively, or an average of 1,111 hours—nearly double the average of all farms. Farm 12 had high labor requirements in pruning on account of purchase of an adjoining orchard which needed more pruning. Then, too, since there was nothing but orchard work on this farm the labor had little alternative use.

TABLE 6—*Monthly distribution of man labor in pruning on twelve farms in 1927.*

	Farm Number													
	1	2	3	4	5	6	7	8*	9	10	11	12	Total†	%
April	21	545¾	14	222	66½	46	19	54½	62	61½	90	182	1,329¾	37.68
May		103½		14	3½				47	19½		109½	297	7.97
June														
July	3												3	.08
Aug.	16½												16½	.44
Sept.		3											3	.08
Oct.														
Nov.							40						40	1.07
Dec.		85½			30½		303½						419½	11.25
Jan.	4	109			36½		300½						450	12.07
Feb.		107½			42	8½							158	4.24
Mar.	109	298½	118½	63½	54	66¾	301						1,011¼	27.12
Total	153½	1,252¾	132½	299½	233	121¼	964	54½	109	81	90	291½	3,728	

*Ill in 1927. Time given is for 1926.

†Farm 8 not included.

Orchard 8, on the other hand, spent a very small amount of time on pruning; only 151 man hours per 1,000 mature trees were used one year, and due to illness the next spring no time was devoted to pruning. As an average for the three years, three farms put less than 400 hours per 1,000 mature trees, seven farms between 400 and 600 hours, and two over 600 hours. The average for all the farms was 474 hours per 1,000 mature trees in 1926, 576 in 1927 and 643 in 1928. The average for all farms for the three years was 567 hours.

The great variation between orchards is not due to a difference in speed of work but to amount and type of pruning. The men in Orchard 2 with a high labor requirement per mature tree units work as rapidly, if not more rapidly, than most orchardists; but the work is done more intensively and perhaps more thoroughly. It seems possible that some orchardists may be too particular, that detailed pruning of small branches, although desirable from the point of view of plant physiology, does not actually give sufficient benefit to justify the cost. The actual difference in results if somewhat larger branches are cut out is difficult to measure, but it is thought that in pruning on the larger orchards there is need of a different viewpoint which will be discussed elsewhere in this bulletin.

Pruning per 1,000 mature trees in Orchard 7 varied from 174 man hours in 1926 to 593 in 1927. Orchard 3 varied from 709 in 1926 to 281 in 1927. This lack of uniformity can be accounted for by the fact that pruning is somewhat indefinite as to annual requirements, and the orchardist if crowded with work may delay some pruning until the next year. They may all plan to prune systematically about so much each year; but, as an actual fact, pruning is fitted in between jobs that are more definite as to time requirements. It is noticeable that construction of buildings, pleasure trips, opportunities to use team or trucks to financial advantage, or other orchard operations have first choice for the orchardist's time. But since this is the case, those who are irregular from year to year and fit pruning into other opportunities for financial gain are actually getting the pruning done cheaper than is indicated by comparison of hours of labor, as they are using time in pruning that has less value. It is marginal time to a large extent. There may be losses in yields due to irregular pruning, but if so, it is difficult to secure evidence. And as far as any indication from a three-year study is concerned, those who prune the most irregularly and for that matter those who do very little pruning seem to be getting as good yields and as high quality of fruit as those who are regular and do much pruning. Pruning is recognized to be a long-time task. It is possible that those who prune most are laying the foundation for greater profits 5 or 10 years hence. The writers are unable, however, to find visible evidence of this fact from present appearances of the orchards.

In general, on the larger fruit farms the labor on pruning is spread over the available period, while on the smaller farms the operation is done in April and May when conditions are more ideal. As shown in Table 6 the large farms 2 and 7 and the medium-sized Orchard 5 did considerable pruning in December, January and February. On the

other hand, the small farms 8, 9, 10, 11 and 12 did all the pruning in April and May. Probably the larger the orchard the greater will be the necessity for spreading out the time on pruning to take advantage of all available good weather from November to May.

During the winter months, the time which can be devoted to pruning is restricted, of course, to short days of good weather. We have no measure of the relative efficiency, but the men claim they are handicapped in the winter and that they not only accomplish less but that the work is of such a nature that in cold weather the task is very disagreeable. Consequently, the orchardist may prefer to work in the woods rather than prune trees in December, January and February and then may put a crew in the orchard to prune in the spring. This is probably a more efficient way of getting the work done providing there are sufficient men trained to prune and providing other profitable work is available in the winter.

On the smaller farms, the operator does practically all the pruning. In the case of the larger farms the regular help have acquired skill and experience. Fortunately there is much leeway as to time since the work can be done during December, January, February, March and April. Thus, while pruning requires more than ordinary ability and skill, the task can be spread over this long period of five months, making it possible for the operator and one or more trained helpers to care for a large orchard. And while the operation requires a rather large amount of tedious painstaking labor, if the men work consistently during the time available for pruning, demands for this task need not limit the size of an orchard.

If we assume that, on the average, the weather conditions permit 80 hours per month for pruning in December, January and February, and 120 hours in March and April, then a man could put in advantageously 480 hours per year in pruning trees.

Since, however, other orchard operations such as spraying must be done in some of this good weather, it is probable that an individual cannot safely plan on an average of more than 450 hours of pruning per skilled workman.

Assuming that the average labor of pruning on the individual farms is the essential requirement for that orchard, it is interesting to study the actual method of handling the management problem.

Orchard 2, with 2,835 trees of all ages in 1927 or the equivalent of 991 mature trees, used 849 total hours in 1926, 1,254 hours in 1927, and 1,186 in 1928, or an average of 1,111 hours per year. Pruning would probably require on this basis the service of three skilled men in the favorable weather in the five months. However, since there are five or six men on this farm who are skilled in pruning, the operator and the men work in the woods most of the winter, pruning some at odd times or in very favorable weather. Then in the spring the large crew of experienced men prune trees in all available weather.

Orchard 7, with 4,315 trees in 1927 equivalent to 1,625 mature trees, put only 259½ hours on pruning in 1926, 964 in 1927 and 722 in 1928. It would appear that two skilled men could do this work in

the available time; actually three men have pruned during part of the available period.

Orchard 1, with 1,191 trees in 1927 equivalent to 550 mature trees, used 265½, 153½ and 498 hours respectively in the three years. The average of approximately 306 hours per season could be done by one man. Actually the operator has done most of the pruning alone.

As shown above, the weighted average time on pruning was 567 hours per 1,000 mature trees. If the time available per season were roughly 450 hours, one skilled man could expect to prune approximately 800 mature trees per season by working at all available times. It is possible to use some unskilled help in pruning if the skilled worker will designate the larger branches to be removed and supervise the

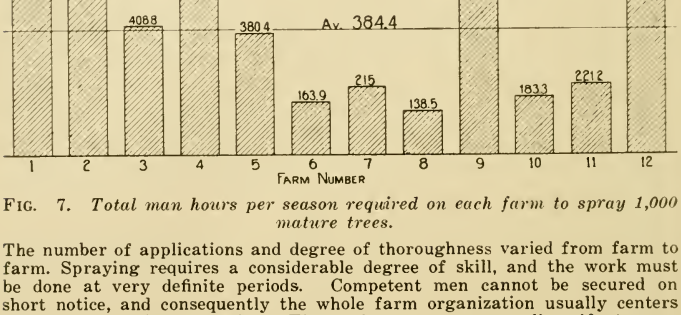


Fig. 7. *Total man hours per season required on each farm to spray 1,000 mature trees.*

The number of applications and degree of thoroughness varied from farm to farm. Spraying requires a considerable degree of skill, and the work must be done at very definite periods. Competent men cannot be secured on short notice, and consequently the whole farm organization usually centers about the spraying operation. Either the operator must diversify to provide productive employment for the spraying crew in slack orchard periods, or he must contrive, as by the use of dusting, to get the work done within the necessary time limits without keeping a large crew. In view of these facts, improvements in the efficiency of spraying as by the adoption of nozzles of large capacity, or improvement in the facilities for mixing materials and refilling the tank constitute a very great economy in the whole orchard program.

work of the unskilled men in addition to his own pruning. In this way, with some unskilled help, a skilled fruit man could prune 1,000 mature trees per season.

SPRAYING

Spraying represents the most difficult and intricate problem in orchard management. It is the one operation that probably is most important in determining the best unit or size for any individual farm. The spray problem has been the chief factor in the decline of the small farm orchard and seems to be the limiting operation in the commercial orchard. One could almost generalize and state that if the orchard operator can get his trees sprayed thoroughly and efficiently at the

TABLE 7—*Total man hours used in spraying on twelve farms.*

Farm Number	Man Hours								
	Total			Per 1,000 mature tree equivalent				Per 1,000 bushels expected normal yield	Per 1,000 bushels actual yield
	1926	1927	1928	1926	1927	1928	Average	Average	Average
1	328	279	346	652.1	506.4	578.7	577.0	77.8	77.
2	533	326	838	571.6	330.5	808.8	573.9	96.3	61.9
3	195	224	162	454.5	474.0	311.9	408.8	80.5	85.
4	266	230	360	634.8	507.7	734.7	628.5	103.2	79.7
5	131	116	201	355.7	294.6	483.2	380.4	62.5	42.9
6	71	91		148.8	177.9		163.9	27.2	39.
7	413	277	357	277.4	170.8	203.1	215.0	37.1	43.2
8	46	58		128.1	148.0		138.5	26.9	14.3
9	67	134		475.2	842.8		670.0	128.8	61.8
10	40	38	44	189.6	170.5	190.0	183.3	30.2	44.5
11		59	98		172.2	267.0	221.2	31.8	65.5
12		133	308		364.0	787.0	583.3	106.0	106.8
Total	2,090	1,965	2,714						
Average				392.2	303.5	467.4	384.4	64.3	58.4

right time, he will have little trouble with the other operations. The number of trees the operator can spray with his equipment will determine the type and size of many fruit farm organizations.

The spraying operation is of such importance not because of the total time required to spray an orchard but because of the very exacting demands for skilled labor during very definite short periods. Certain sprays to be effective must be applied within a very brief range of time, and these short spray periods become the peak in skilled labor requirements. The task requires a responsibility that cannot be trusted to the inexperienced hired man.

Even though experienced men might be available, the problem is further complicated by the requirement of special high value equipment. The expense of maintaining a large efficient sprayer is great enough to warrant very careful planning to make each machine as effective as possible.

The amount of spraying required is somewhat indefinite. There was little uniformity in the number of sprays used, but there is some evidence that spraying procedure is tending toward standardization. The ever increasing need to protect fruit and tree from pests and diseases is tending to make more sprays and more thorough spraying essential.

It may be that individual men have adjusted their spraying somewhat to the needs and requirements of their particular orchards, taking into account differences in location, infestation and varieties.

Farm 1 sprayed seven times each year. Because of nearby neglected orchards, the operator considered the additional sprays an insurance against disease or insect infestation.

Orchards 2 and 4 are in an area of dense tree population. There are many odd and early varieties to contend with in the community. The soil is heavily fertilized, and the trees have dense foliage. Both these men spray thoroughly and carefully in order to control scab and pests.

Orchards 5 and 8 are on slopes with good air drainage, and fewer sprays have seemed to protect the orchards fairly well. Orchard 8, with only two sprays in 1927, had a very large crop of fine quality fruit. It is doubtful if two sprays per season will suffice as a permanent practice.

Spraying accounted for 18 per cent. of the man hours, 40 per cent. of the horse hours and approximately 30 per cent. of the current operating costs prior to harvest. The average man labor requirement per 1,000 mature tree unit was 384 hours. The highest labor requirement per 1,000 mature trees was on Farm 9, where two sprays were applied with a hand outfit; and the lowest was on Farm 8, which put on two sprays with a medium-sized spray outfit (Table 7). Farms 2 and 4 applied about the same number of sprays, and both did a thorough job in 574 and 628 man hours respectively. Farms 6 and 10 with a large proportion of bearing Baldwins had a low requirement. Farm 7 used dust in place of the later sprays and thus decreased the labor needed.

When computed by years, Farm 4 was highest in 1926 with 635 man hours; Farm 9 was highest in 1927 with 843 hours; and Farm 2 was

highest in 1928 with 869 hours. The lowest was Farm 8 with 128 hours in 1926 and 148 hours in 1927. In 1928, Farm 10 was lowest with 190 hours.

In two instances, on the same farm, the differences in total hours varied greatly from year to year. Farm 2 devoted 572 hours, 330 hours and 809 hours, respectively in the three years. The low requirement in 1927 was due to omission of some sprays on trees with low yields. In 1928, extra oil sprays, used to check the red mite, account for the high labor requirement.

A dusting machine held in reserve may enable a man to cover his orchard in a pinch without extra skilled men or extra horses.

Farm 7 made some progress in efficiency of applying the liquid spray. In 1926, a three-man crew was used, one driver and two sprayers. The tank was filled at the barn by means of a ¾ inch hose. In 1927, a two-man crew was used and a storage tank with 3 inch hose connection was put up. The total time in dusting and spraying per 1,000 tree unit on this farm in 1926 was 278 hours, and in 1927 was 171 hours. A considerable portion of this reduction in time is due to the indicated changes. On large tracts, the installation of several filling stations fed by a small pipe and automatic float valve would be advisable.

These data have to do with the actual situation on the several farms; but because the farms are not using the same sprays, the results should

not be used to study efficiency in labor. At least it would require several years of careful check on disease control together with labor and other requirements before conclusions would be justified.

Since all operators applied the calyx spray to all trees the time required indicates the relative time used per mature tree unit. However, it does not indicate how thoroughly the work was done, and hence even this is not an accurate measure of efficiency.

As shown in Table 8, the variation between farms for this one spray is considerable. Farm 7 used dust for this application and is not directly comparable with the others. Farm 9 used a hand sprayer mounted on a wagon and required 312 hours in 1926 and 289.3 hours

TABLE 8—*Man labor used in applying calyx spray on twelve farms.*

Farm Number	Man hours							
	Total			Per 1,000 mature trees				Per 1,000 bushels expected normal yield
	1926	1927	1928	1926	1927	1928	Average	Average
1	65	76	80	129.2	138.2	134	133.9	18.1
2	189	120[3]	202[3]	202.8	121.8	195.7	173.2	29.1
3	48	90[2]	60	111.9	191.7	115.2	139.6	27.5
4	81	66	108	193.3	145.7	220.4	187.2	30.8
5	68	57[2]	65[2]	184.3	146.7	157.4	162.3	26.7
6	29	29[1]	*	60.8	57.0	*	58.8	9.8
7	32	36[2]	17[2]	21.5	22.5	10.0	17.6	3.0
8	46	40[2]	*	128.1	103.3	*	115.2	22.4
9	44	46	*	312.1	289.3	*	300.0	57.6
10	21	17[2]	21	99.5	79.5	91.7	90.2	14.8
11	*	29	41[2]	*	84.3	113.1	99.2	14.2
12	*	47[2]	63[2]	*	130.5	162.0	146.8	26.7
Total	623	657	659[3]					
Average				116.9	101.5	113.6	110.2	18.4

*No record.

in 1927 per 1,000 mature trees. On the other hand, Farm 2 with a large power outfit used 202.8 hours, 121.8 hours and 195.7 hours respectively for the three years. Orchard 4 with large power sprayer used 193 hours, 145.7 hours and 220 hours respectively. Farm 8 used 128 hours and 103 hours respectively with a smaller machine. Farm 1 used 128.2 hours, 138.2 hours and 134 hours respectively in three years with a small machine. Farm 10 with a medium-sized sprayer used 99.5 hours, 79.5 hours and 91.7 hours respectively.

Farms 2 and 4, with large machines, used more material than Farms 1, 8 and 10. They did a more thorough job of spraying and covered the foliage with more liquid than the others. Is this larger amount of material essential in commercial orcharding? Do Orchards 1, 8 and

TABLE 9—*Distribution by five-day periods of total man hours in spraying on all orchards in 1927.*

Man hours

Farm Number

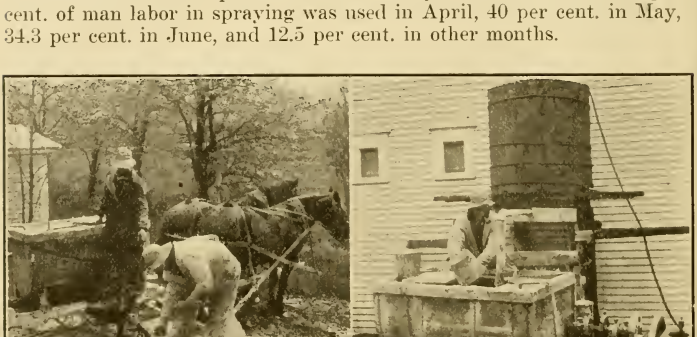
Date	1	2	3	4	5	6	7	8	9	10	11	12	Total
Apr. 1-5				8									8
6-10													
11-15		4											4
16-20							32						32
21-25	10	24¼					29½						63¾
26-30		35	32	27			41		18				153
May 1-5	15		22	39	25		19½	17½	16			24	178
6-10	35	53¾		27	25	15½	33½		20				209¾
11-15	12					1½	22½			6		34	76
16-20					2						2		4
21-25					19								19
26-31	58	114¼	36	66	36½	16	14½	31½					372¾
June 1-5	18	6½	33			13¼	22	9	34	1½	29		166¼
6-10			21½				8		12	16		47½	105
11-15	10						16½				11		37½
16-20				63			9½				15¾	1½	89¾
21-25		89¾	62¼		1					14	1½	6½	175
26-30	14		1½		7	32						2	56½
July 1-5	44½					8						3	55½
6-10	16		15½			5			34				70½
11-15												11½	11½
16-20													
21-25												2½	2½
26-31													
Aug. 1-5							11						11
6-10							9½						9½
11-15	46												46
16-20													
21-25													
26-31													
Mar. 1-5													
6-10													
11-15													
16-20													
21-25													
26-31							8½						8½
	278½	327½	223¾	230	115½	91¼	277½	58	134	37½	59¼	132½	1,965¼

TABLE 10—*Distribution by months of man hours in spraying on all farms.*

	1926		1927		1928		Total	
	Hours	Per Cent.	Hours	Per Cent.	Hours	Per Cent.	Hours	Per Cent.
April	165¼	7.9	260¾	13.3	468¼	17.3	894.25	13.2
May	836	40.0	859½	43.7	1,012¾	37.3	2,708.25	40.0
June	932½	44.7	630	32.1	756¾	27.9	2,319.25	34.3
July	94¾	4.5	140	7.1	369¼	13.6	604.	8.9
August	61½	2.9	66½	3.4	82	3.0	210.	3.1
Other			8½	.4	25	.9	33.5	.5
Total	2,090	100	1,965¼	100	2,714	100	6,769.25	100

10 apply this spray sufficiently well for all practical commercial purposes? From a long time point of view is the larger amount the better plan, or is this another case in which the orchardist is too intensive? There is in this brief study not sufficient evidence to solve the problems.

Table 9 shows the distribution of labor used in spraying on the various orchards in 1927 by 5-day periods and indicates the great differences between farms. Farms 8, 10 and 11 confine all their spraying to about a six weeks' period, while Farms 1, 7 and 12 put on spray over a three months' period. For all the years (Table 10) 13.2 per cent. of man labor in spraying was used in April, 40 per cent. in May, 34.3 per cent. in June, and 12.5 per cent. in other months.



The operator of Farm 7 cut the time requirement in refilling spray tank by building special outfit to insure quick loading. A comparison of the picture on the left with that on the right indicates progress in method from 1926 to 1927.

On the average there is approximately the following time period for the various sprays: dormant, 10 days; prepink, 5 days; pink, 5 days; calyx, 5 days; 1st cover, 12 days. Since, however, there may be considerable rainy or windy weather, the large orchardist should be equipped with machinery and personnel to cover the orchard within a three day period. To do this may necessitate additional equipment to make water available and special lights for night spraying. On account of the large investment in machinery, the urgent need in certain years to take advantage of every minute of favorable weather in brief periods is obvious. Farm 2 has made provision in several convenient places in the orchard for a supply of water, and consequently the crew can spend a large proportion of the time in actual spraying.

Skilled men cannot ordinarily be had for short periods. The larger the crew of skilled men required to put on a spray over all the trees, the greater may be the management problem in providing productive

employment at other times to these men. Therefore, every efficiency made in spraying that will shorten the time required and yet prove effective is more important than the mere saving of so many hours would indicate. Any considerable saving in requirement of skilled men in the limited spray period may ease up a serious and difficult management problem. Then, too, this efficiency may avoid the need of additional high-priced outfits.

Orchard 2 normally had six to seven regular men on account of other crops, and these were available at any time for spraying. Two outfits with three men each can spray the orchard in less than 40 hours of total spraying. Sufficient horses are also available for two crews. If it were not for the other enterprises on this farm, it would be best to reduce the spray crew to the minimum number that could do the work by using all available time. Three men using one large sprayer equipped with large capacity quad nozzles could cover the orchard almost as rapidly and in all probability about as thoroughly as the six men using small capacity guns on two machines. Or the smaller crew might spray as much as possible and supplement with dust. Consequently, the problem would be simplified to finding productive work for three men and one team in slack orchard periods.

In Orchard 7 with a large number of trees the management problem has been met by substituting dusts for some of the liquid sprays. By this means the size of crew is reduced, and it becomes unnecessary to provide productive employment for a number of men during the slack periods between applications. The duster, which requires one horse and two men, makes it possible to cover the large orchard in 13 to 18 hours of actual operation. It was used for the early sprays in case of necessity and for all late applications. Considerable expense in maintaining a team or tractor for a second sprayer, which would be necessary if liquid sprays were used exclusively, has been avoided. The importance of the dusting machine from the point of view of management is evident. The value of dusting cannot be judged solely from the number of hours of labor involved, the cost of material, and the degree of control. Its relation to the management problem of the whole season must also be considered.

Spraying machines are now on the market which will cover the trees almost if not quite as rapidly as does the dust. These are much more expensive than dusting equipment of equal capacity, and in the case of the liquid sprays a much larger proportion of the time is consumed in refilling.

Horse Hours

Spraying represents the largest demand on horse labor, requiring on the 12 farms an average of 328 hours per 1,000 mature tree units, (Table 21) or about 40 per cent. of the total requirements up to harvest. The total amount of horse labor in spraying is relatively unimportant; but on account of the demand for horses for short definite periods, horse labor does become a problem, especially on the large, highly specialized apple farms. If the orchard is of medium size so that one spray outfit can do the work, the one team can do in addition

all the other orchard work together with many other farm tasks during the year. But when the farm orchard requires two teams to do the spraying, this extra team is not needed for any other orchard work, and maintaining it for spraying only becomes expensive.

Farm 2 uses two teams in spraying the 2,835 trees, equivalent to 991 mature tree units; but in this case the teams can be used on other productive work, other crops, lumbering, etc. In the case of Farm 7 with 4,315 trees, equivalent to 1,625 mature tree units, only one team is used. In this case, the orchard is highly specialized, and there is little other productive use for a team. To maintain an extra team just for spraying would be very expensive. As previously noted, the operator of this farm has been able to get along with one team by using a dusting machine. Without a duster an additional spray machine and another team would probably be needed besides the additional crew previously discussed. This operator might rig up an old truck for power for one sprayer and thus avoid the expense of maintaining the extra team for a whole year, but such an arrangement is not altogether satisfactory.

Farm 9 with 663 horse hours per 1,000 mature tree units had the highest requirement in spraying, and Farm 7 which used the duster had the lowest with 161 hours.

Cost of Maintaining Spraying Machinery

The several farms were equipped with a variety of machines. A specific example taken from Farm 2 may be of interest. The equipment consisted of two 5-horse power spraying machines, valued at the outset at $930 (Table 11). During the period of the study labor used in repairing the machines amounted to $97.20, and the repair parts cost $80.56. At the end of the period the machines were valued at $731.80. Their actual spray efficiency was probably equal to that at the beginning of the period since the new parts installed had maintained them in perfect operating condition. Interest for the period amounted to $124.64, bringing the total cost of maintenance for the two machines over the 3-year period, including depreciation of approximately $200, to $500.60. From the record of man hours in spraying it is indicated that each machine is operated approximately 12 days per year. Records of gas and oil were not kept accurately but are estimated to amount to $42. Hence the cost per day of actual operation for the use of the machine without man or horse labor and without the materials was roughly five dollars a day.

With a crew of three men and a team the total cost of operating the machine amounts roughly to $20 per day. Under ordinary circumstances with reasonably convenient water supply, each machine applied 2,000 gallons per day and sometimes more. The actual cost of putting on the material is, therefore, in the neighborhood of one cent a gallon, which on the whole is a very reasonable figure.

The average investment in spray equipment was $356 per farm in 1926. The two large outfits on Farm 2 valued at $930 represent the maximum and Farm 9 with a hand outfit on a wagon had the minimum investment of $60. Three farms had on the average less than $100 invested in spray outfits, and four had over $400.

TABLE 11—*Cost of spray machinery for three-year period.*

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Value-Spray machinery-beginning ...	$75.00	$930.00	$75.00	$800.00	$250.00	$77.00	$415.00	$227.00	$60.00	$250.00	$200.00	$500.00	$3,859.00
Value-Spray machinery-end	40.00	731.80	25.00	608.00	175.00	56.68	315.40	185.88	40.00	175.00	172.00	400.00	2,924.76
Depreciation	35.00	198.20	50.00	192.00	75.00	20.32	99.60	41.12	20.00	75.00	28.00	100.00	934.24
Depreciation	35.00	198.20	50.00	192.00	75.00	20.32	99.60	41.12	20.00	75.00	28.00	100.00	934.24
Man labor (40c)	16.00	96.40	42.80	7.60	16.20	3.00	44.80				20.40	29.80	277.00
Horse labor (20c)*	1.80	.80	2.90		2.50						8.00		16.00
Expenses	21.50	80.56	5.00	34.38	8.00	17.49	17.00	21.07				35.00	240.00
Total cost	74.30	375.96	100.70	233.98	101.70	40.81	161.40	62.19	20.00	75.00	56.40	164.80	1,467.24
Interest	8.62	124.64	7.50	105.60	31.88	6.68	54.78	20.64	5.00	31.88	18.60	45.00	460.82
	82.92	500.60	108.20	339.58	133.58	47.49	216.18	82.83	25.00	106.88	75.00	209.80	1,928.06
Gas and oil estimated	23.06	42.32	12.66	17.16	10.80	4.16	21.52	5.20		3.38	3.86	14.92	159.04
Total operating cost	105.98	542.92	120.86	356.74	144.38	51.65	237.70	88.03	25.00	110.26	78.86	224.72	2,087.10
Total cost 1,000 mature trees	64.23	183.48	84.99	261.92	122.67	52.17	48.79	117.22	83.33	167.06	110.91	297.25	118.52
Total cost 1,000 boxes expected yield .	8.66	30.79	16.75	43.03	20.18	8.65	8.42	22.79	16.02	27.50	15.93	54.02	19.83
Total cost 1,000 boxes actual yield ...	8.56	19.80	17.67	33.22	13.82	12.43	9.79	12.12	7.69	40.57	32.86	54.44	17.99

*Horse labor charge is for hauling sprayer to repair shop.

Depreciation was estimated in each case with reference to the condition of the machine. A total of $934 was allowed for depreciation for the three years, or an average of $30 per farm per year. The labor for repairs at 40c per hour for all farms was $277, horse labor for repairs $16, and expense for repair parts and shop work was $240. Interest on investment at 5 per cent. was $461, and estimated gasoline and oil came to $159.04, making a total for spray machine costs of $2,087.10.

On this basis, the average cost was $118.52 per 1,000 mature tree units, $19.83 per 1,000 boxes normal yield and $17.99 per 1,000 boxes actual yield.

No. 12 had a high machine cost of $297.25 per 1,000 trees on account of a large machine on a relatively small orchard. The situation here as is often the case is unavoidable. The grower in purchasing a durable machine must anticipate the needs of the orchard ten or more years in advance.

No. 2 had a large cost on account of the large amount of total spraying done which made the repair work on two machines relatively high. The machine cost was lowest on Farm 9 where a hand pump was used but, of course, the expense of operating the outfit more than made up for the low cost.

Spray Material Cost

As described under labor in spraying there were great variations in the number of sprays applied. In addition, certain farms put on a greater amount of spray per application. Farm 2 not only uses a larger total quantity of liquid than any of the farms, but in addition an oil spray, an expensive material, was put on one year for red mites. Farm 7 used dust which is higher in cost than liquid spray material.

When computed on the basis of mature tree equivalent, (Table 23) the average spray material cost was $436.40 per 1,000 trees. Nos. 2 and 7 had a cost of over $500 per 1,000 trees. Farms 1, 3, 4, 9 and 12 had costs between $300 and $500. Farms 5, 6, 8, 10 and 11 had costs below $300.

When computed on a basis of normal expected yield, the average cost of spray material was $73. Farm 7 had a cost of $121.84 per 1,000 boxes. Farms 2, 3, 4, 9 and 12 had costs between $50 and $100 and farms 1, 5, 6, 8, 10 and 11 had costs under $50 per 1,000 boxes.

When computed on a basis of actual yield, the average cost of spray material was $66.24 per 1,000 boxes. No. 7 had a cost of $141.73 per 1,000 boxes. Farms 2, 3 and 12 had costs between $50 and $100. Farms, 1, 4, 5, 6, 8, 9, 10 and 11 had costs below $50.

The formula used for most sprays was 2 to 2½ gallons liquid lime-sulphur, and 3 to 4 pounds lead arsenate per 100 gallons of water. Some also added one pound calcium caseinate spreader, and rarely nicotine sulphate at the rate of ¾ to 1 pint was deemed necessary. Eight to nine pounds of dry lime-sulphur was sometimes used in place of the liquid concentrate.

Total Cost of Spraying

With the assumed rate per hour, the total cost of spraying averaged

$774.96 per 1,000 mature tree units, (Table 24). The lowest cost was $376.51 on Farm 11 and the highest was $1,089.70 on Farm 2.

On the basis of normal yield, the average cost was $129.63 per 1,000 boxes and on the basis of actual yield, the cost was $117.65 per 1,000 boxes.

BRUSH DISPOSAL

The operation of brush disposal is not important from an orchard management viewpoint because it can be done at anytime within a rather long period in the spring, does not require skill, and the total time used is not large. On most farms the work was fitted into or between operations that were more definite as to time. There are usually many days in the spring when the weather is too disagreeable to prune, and yet when one can pick up brush to advantage. Then again, up to the period of the first spray the task can be fitted into slack periods.

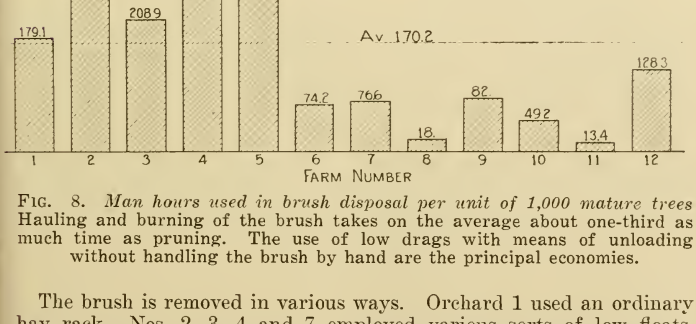


FIG. 8. *Man hours used in brush disposal per unit of 1,000 mature trees* Hauling and burning of the brush takes on the average about one-third as much time as pruning. The use of low drags with means of unloading without handling the brush by hand are the principal economies.

The brush is removed in various ways. Orchard 1 used an ordinary hay rack. Nos. 2, 3, 4 and 7 employed various sorts of low floats. Farm 7 used a chain to unload. The chain is laid on the float before the brush is loaded, and then the horse power is used to roll the brush off. Farm 5 burns some brush in the orchard on account of the difficulty of getting around in rough and rocky positions. On the small orchards, Nos. 9, 10, 11 and 6, some brush was left on the edge of the field.

Man Hours

Brush hauling accounted for approximately 8 per cent. of the man labor prior to harvest, as compared to 26 per cent. for pruning. In other words, one hour was required for disposing of brush to each three hours of pruning. In some of the small orchards with scattering trees, practically no effort was made in disposal of brush, while in other orchards the time on brush disposal amounted to 60 per cent. as much as the pruning requirement.

Man labor in brush disposal (Table 20) averaged 170 hours per 1,000 mature tree units. Farm 11 was lowest with 13 hours. Farm 4 was highest with 341 hours. In the first case brush was disposed of along the nearby fence rows.

An average of 101 hours of horse labor was used per 1,000 mature tree units in brush disposal (Table 21) and varied from 10 hours for Orchard 11 in which little attention was given to brush to 172 hours for Orchard 4. Based on expected yields, an average of 17 hours was used per 1,000 boxes, and based on actual yields, 15.4 hours.

With assumed rates per hour for man labor, horse labor, etc., the weighted average cost was $88.71 per 1,000 mature trees, $14.84 per 1,000 boxes expected yield and $13.45 per 1,000 boxes actual yield. The cost on the basis of actual yield varied from $2.18 on Farm 11 to $23.65 on Farm 3 per 1,000 boxes.

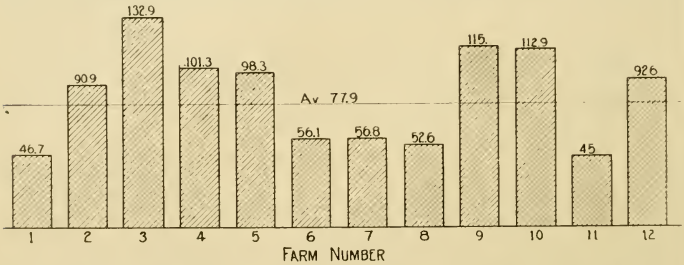


Fig. 9. *Man hours used in applying fertilizer per unit of 1,000 mature trees* Fertilization is an important operation but consumes little time. Peak demands for labor and power are avoided by the use of the sod mulch system, in which the relatively small task of spreading fertilizer is the only soil cultural operation of early spring.

FERTILIZING

Fertilizing the apple orchard is a minor operation in the spring. While considerable skill and judgment is required in determining the amount to use, the actual operation can be done by unskilled help; and within the limits of about three weeks, more or less, it is optional as to time. As actually practiced by the twelve farmers there is no particular regularity as to time of application. The operation accounted for about 4 per cent. of the man labor prior to harvest. In most cases, the fertilizer was applied by hand around each tree. Farm 4 broadcasts a complete fertilizer over the entire orchard area.

An average of 78 man hours per 1,000 mature tree units was used in application of fertilizer (Table 20). The requirement varied from 45 hours on Farm 11 to 133 hours on Farm 3. The higher amount is due to the application of available hen and cow dressing.

Horse Hours

The horse hours used in fertilizing are relatively unimportant as the total time is small and the work is generally done in slack periods.

The average of the three years was approximately 37 hours per 1,000 mature trees (Table 21), with 6 hours per 1,000 boxes normal yield and 5.6 hours per 1,000 boxes actual yield.

Fertilizer Cost

Farm 4 applied a complete fertilizer broadcast over the whole area of the orchard at the rate of approximately 1,500 pounds per acre. Farm 2 used a complete fertilizer spread around each tree. All the other farms used either nitrate of soda or sulphate of ammonia around each tree.

Computed on the basis of mature tree equivalent (Table 23) the fertilizer cost was approximately $500 per 1,000 trees. Farm 4 had an expense of $1,897 per 1,000 mature trees. This farm has been fertilized heavily for many years and considerable hay has been taken from the orchard. The practice may have paid in the past, but it would be better to discontinue it now. If this farm is excluded, the average cost of fertilizer is $376 per 1,000 mature trees.

Farms 2, 3, 9, 10, 11 and 12 had more than $400 cost per 1,000 trees. Farms 5, 7 and 8 had a cost between $300 and $400. Farms 1 and 6 had less than $300 per 1,000 trees.

Computed on the basis of expected normal yield, the average cost for fertilizer was $83.54 per 1,000 boxes. Excluding Farm 4, the average cost was $63 per 1,000 boxes. Farms 2, 3, 8, 10 and 11 had costs between $60 and $100 and Farms 1, 6 and 7 had costs below $60.

Computed on the basis of actual yields, the average cost of fertilizer was $75.81 per 1,000 boxes. Excluding Farm 4, the average was $58 per 1,000 boxes. Farms 3, 4, 10 and 11 had costs above $100 per 1,000 boxes. Farms 2, 3, 5, 8, 10, 11 and 12 had costs between $60 and $100 per 1,000 boxes. Farms 1, 6 and 7 had costs below $60.

Since the orchards are for the most part in sod, it is agreed that nitrogen fertilizer is essential. The materials most commonly used are nitrate of soda and sulphate of ammonia. The quantity varies widely. Some growers with trees 15 to 20 years of age use but three or four pounds of the nitrate, and others with full bearing trees as much as 16 pounds. When sulphate of ammonia is used, since the price is usually about the same as that of the nitrate, the tendency is to apply the same quantity although the actual nitrogen content is higher. Adding the other elements in the proportion of a 7-8-5 complete fertilizer practically doubles the cost.[1] There is no evidence that the additional material influenced yield or quality. The two operators who applied a complete fertilizer secured good yields but no higher yields than several who applied only nitrate of soda.

SOIL MANAGEMENT PROGRAM

Cultural operations are devoted chiefly to the conservation of moisture, maintenance of organic matter and rendering available of the nitrogen and other elements in the soil.

The problem of orchard soil management has been solved in different regions by the adoption of different practices. In some areas

[1]The sulphate of ammonia cost approximately $6 per ton, the nitrate slightly more, and complete fertilizer about $40.

TABLE 12—*Total horse, track and tractor hours used in orchard soil management operations on twelve farms for three years.*

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Horse hours cultivating	598	1,473	190.2	1,041.0		16.0							3,318.2
Tractor hours cultivating			159.7				31.5						191.2
Truck hours cultivating			14.0				32						46.0
Horse hours mowing	93	229	209.5	182.0	48.0	36.0	381.0	180.0	70.5	12.0	80.0	166.5	1,687.5
Horse hours mulching	85	23.2	75.5			73.0	64.0	4.0		1.0		27.5	353.2
Truck hours mulching			9.0				4.0						13.0
Total horse hours	776	1,725.2	475.2	1,223.0	48.0	125.0	445.0	184.0	70.5	13.0	80.0	194.0	5,358.9
Total tractor hours			159.7				31.5						191.2
Total truck hours			23.0				36.0						59.0
Horse hours per acre	9.7	14.3	5.1	15.1	1.2	1.9	2.7	3.6	4.2	.2	2.9	2.7	6.2
Tractor hours per acre			1.7				.2						.22
Truck hours per acre			.2				.2						.07
Horse hours per tree (1,000)	217.2	205.6	74.0	360.2	18.3	29.6	34.4	75.7	64.3	8.7	55.2	68.0	105.3
Tractor hours per tree (1,000)			24.8				2.4						37.6
Truck hours per tree (1,000)			3.6				2.8						11.6
Horse hours per mature tree equivalent	470.3	583.1	334.2	897.9	40.8	126.3	91.3	245.0	235.0	19.7	112.5	256.6	304.3
Horse hours per 1,000 boxes, expected normal yield	63.4	97.8	65.8	147.5	6.7	20.9	15.8	47.6	45.2	3.2	16.2	46.6	50.9

TABLE 13—*Total man hours used in orchard soil management on twelve farms for three years.*

	Farm number												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Cultivating	448.5	1,032.5	499.25	1,042.5	4.0	8.0	65.5						3,100.25
Machine mowing	46.5	114.5	110.25	91.0	48.0	18.0	190.5	168.0	35.25	12.0	40.0	100.0	974.0
Hand mowing	202.0	406.0	63.00	619.0	412.5	9.0	572.5	72.0	92.75	75.5		707.5	3,231.75
Mulching	88.0	59.5	197.25	131.0	14.0	89.5	97.5	4.0		2.0		201.0	883.75
Total hours	785.0	1,612.5	869.75	1,883.5	478.5	124.5	926.0	244.0	128.0	89.5	40.0	1,008.5	8,189.75
Per acre	9.8	13.4	9.3	23.2	11.8	1.9	5.6	4.8	7.6	1.6	1.4	14.0	9.4
Per tree	220.0	190.0	140.0	550.0	180.0	30.0	71.5	100.0	120.0	60.0	27.6	350.0	160.9
Per 1,000 mature trees	480.0	540.0	610.0	1,380.0	410.0	120.0	190.0	320.0	430.0	140.0	56.3	1,330.0	465.1
Hours per 1,000 boxes													
Actual yield	63.44	58.81	127.2	175.42	45.82	29.96	38.15	33.58	39.38	32.93	16.67	244.31	70.60
Expected yield	64.16	91.45	120.5	227.17	66.88	20.86	32.80	63.18	82.0	22.32	8.08	242.43	77.80

TABLE 14—*Cost of soil management operations on twelve farms for three years at assumed rates per hour for labor and power.*

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Man hours @ 40c	$314.00	$645.00	$347.90	$753.40	$191.40	$49.80	$370.40	$97.60	$51.20	$35.80	$16.00	$403.40	$3,275.90
Horse hours @ 20c	155.20	345.05	95.04	244.60	9.60	25.00	89.00	36.80	14.10	2.60	16.00	38.80	1,071.79
Tractor hours @ $1.50			229.55				47.25						276.80
Truck hours @ 75c			17.25				3.00						20.25
Total cost	469.20	990.05	689.74	998.00	201.00	74.80	509.65	134.40	65.30	38.40	32.00	442.20	4,644.74
Cost per acre	5.84	8.21	7.37	12.32	4.96	1.15	3.06	2.67	3.88	.70	1.14	6.12	5.34
Cost per 1,000 trees	131.31	118.00	107.35	293.96	76.60	17.68	39.36	55.26	59.58	25.72	22.10	154.89	91.23
Cost per 1,000 mature trees	284.36	334.59	485.05	732.74	170.77	75.56	104.61	178.96	217.66	58.18	45.01	584.92	263.76
Cost per 1,000 bushels actual yield	37.92	36.11	100.87	92.94	19.24	18.00	21.00	18.50	20.09	14.13	13.33	107.12	40.04
Cost per 1,000 bushels normal expected yield	38.35	56.15	95.58	120.37	28.09	12.53	18.05	34.80	41.83	9.57	6.46	106.30	44.12

of low rainfall cultivation has been the only practical system, while in other regions, notably New England, the mulch system has been very successful. Most New Hampshire orchards are maintained in sod, but many orchardists cultivate young trees and may occasionally plow up and re-seed a bearing orchard.

It has been customary to think of the cultivation system in which a cover crop is sown and plowed under annually as one in which the organic matter of the soil is well maintained. Recent experiments seem to demonstrate, however, that the losses in organic matter are very serious when the soil is cultivated and that in an orchard where shade interferes with growth of the cover crop, organic matter may not be maintained by this system as well as under sod mulch. The

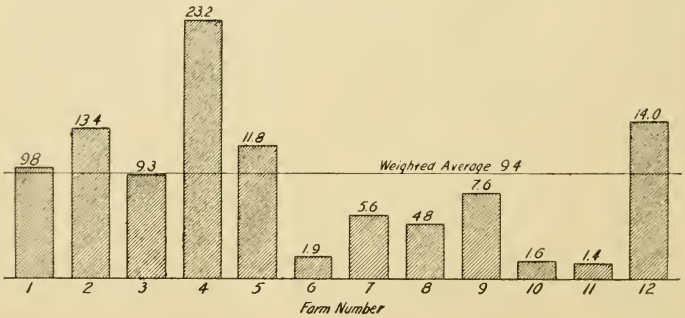


Fig. 10. *Man hours per acre used in soil management operations* The proportion of cultivated orchards was highest on Farm 4. There too, because of liberal fertilization, the grass on sod plots required mowing twice each season. Farms 6 to 12 used sod mulch exclusively, but on Farm 12, which is devoted to apples almost exclusively, marginal time during slack periods was used to cut and haul extra mulch from lowland meadows.

maintenance of organic matter has a very important bearing on the moisture holding capacity of the soil which in turn is of extreme importance to the orchard. Under the mulch system, especially if additional material from outside sources is applied, the total organic content may be kept high; but the material, of course, is not as well incorporated in the soil as is the case when the orchard is tilled.

On all farms for the three years a total of 8,190 hours, or 21.0 per cent. of all labor prior to harvest, was used in cultivating, mowing and mulching (Table 13). Farms 8 and 6 did very little work on moisture control, while Farm 4 used over 38 per cent. of the labor prior to harvest on these operations.

Since it is impossible to secure an accurate check on the efficiency of the culture, the discussion must be largely descriptive.

The weighted average man labor requirement in soil culture was 9.4 hours per acre, with a range of from 1.4 to 23.2 hours. Farm 4 with the highest labor requirement cultivated a large part of the orchard and did considerable work at slack times in fitting up a small addi-

tional area. The time used in the three-year period on this farm is probably about 25 per cent. greater than the normal use of labor on soil management. Farm 5 with 11.8 hours per acre did considerable hand-mowing, because part of the orchard is on rough and rocky land. Orchard 2 with 13.4 hours per acre cultivated the young orchards and did a very thorough job of hand-mowing. Orchard 7 used 5.7 hours per acre. This orchard is laid out conveniently to mow with machines, and hand-mowing was done only where the operator thought it would pay from a moisture control viewpoint.

The weighted average labor requirement per 1,000 trees was 160 hours. Farm 4 was highest with 550 hours, and Farm 6 lowest with 30 hours.

TABLE 15—*Average acres and average number of trees cultivated on twelve farms.*

Farm number	Number of acres			Number of trees		
	Cultivated	Not Cultivated	Total	Cultivated	Not Cultivated	Total
1	8.5	18.3	26.8	274	917	1,191
2	14.3	25.9	40.2	1,124	1,672	2,796
3	10.3	20.9	31.2	864	1,278	2,142
4	10.	17.	27.	262	870	1,132
5		13.5	13.5		875	875
6		32.5	32.5		2,115	2,115
7	1.3	54.2	55.5	128	4,188	4,316
8		25.2	25.2		1,216	1,216
9		8.4	8.4		548	548
10		18.2	18.2		498	498
11		14.	14.		724	724
12		36.1	36.1		1,428	1,428
	44.4	284.2	328.6	2,652	16,329	18,981

In cultural operations the labor requirement is not positively correlated with the age of the tree. Consequently orchards with a large percentage of young trees that are either heavily mulched or cultivated tend to have a higher labor requirement per mature tree equivalent as compared to per tree. The average per 1,000 mature trees was 465 hours.

When related to actual yields for the three years, the average labor requirement per 1,000 boxes of apples was 70¾ hours. All but two farms are below this average. The weighted average number of man hours per 1,000 boxes of normal expected yield was 78.

The period of labor on soil management is not very definite as to time, and there is considerable leeway for the operator to do the work at times when other more definite orchard jobs are not pressing. On diversified farms, the cultivation or mowing of an orchard seriously competes with some crops; but since the work can usually be done by ordinary farm help no very serious management problem is raised.

TABLE 16—*Cost of cultivating for three years on four farms where considerable cultivating was done.*

	Hours Farm number					Cost Farm number				
	1	2	3	4	Total	1	2	3	4	Total
Man labor	448.5	1,032.5	499.25	1,042.5	3,022.75	$179.40	$413.00	$199.70	$417.00	$1,209.10
Horse labor	598.0	1,473.0	190.	1,041.	3,302.	119.60	294.60	38.05	208.20	660.45
Tractor			159.75		159.75			239.62		239.62
Truck			14.2		14.2			10.65		10.65
Total						299.00	707.60	488.02	625.20	2,119.82
Man labor per acre	17.6	24.1	16.2	34.8	23.4	7.04	9.64	6.48	13.92	9.36
Horse labor per acre	23.4	34.3	6.2	34.7	25.6	4.68	6.86	1.24	6.94	5.12
Tractor labor per acre			5.2		1.2			7.80		1.80
Truck labor per acre			.5		.11			.38		.08
Total cost						11.72	16.50	15.90	20.86	16.36
Man labor per 1,000 trees	546.	306.	193.	1,326.	399.	218.40	122.40	77.20	530.40	159.68
Horse labor per 1,000 trees	727.	437.	73.	1,324.	436.	145.40	87.40	14.60	264.80	87.20
Tractor labor per 1,000 trees			62.		21.			93.00		31.50
Truck labor per 1,000 trees			5.		2.			3.75		1.50
Total cost per 1,000 trees						363.80	209.80	188.55	795.20	279.88
Total cost per 1,000 mature trees						$674.52	$933.90	$692.47	$1,441.26	* $926.83

*Average.

TABLE 17—*Cost of soil management operations on trees not cultivated on twelve farms for three years.**

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Man hours	336.5	580.	370.5	841.	474.5	116.5	810.	244.	128.	89.5	40.0	1,008.5	
Horse hours	178.0	252.20	285.0	182.	48.	109.	445.	184.	70.5	13.	80.	194.0	
Truck hours			9.				4.						
Cost of man labor	$134.60	$232.00	$148.20	$336.40	$189.80	$46.60	$324.00	$97.60	$51.20	$35.80	$16.00	$403.4	
Cost of horse labor	35.60	50.40	57.00	36.40	9.60	21.80	89.00	36.80	14.10	2.60	16.00	38.8	
Cost of truck operation			6.75				3.00						
Total labor cost	$170.20	$282.40	$211.95	$372.80	$199.40	$68.40	$416.00	$134.40	$65.30	$38.40	$32.00	$442.20	
Man labor per acre (cost)	$2.45	$2.98	$2.36	$6.60	$4.69	$.72	$1.99	$1.94	$3.05	$.66	$.57	$5.59	$2.74
Horse labor per acre (cost)	.65	.65	.91	.71	.24	.34	.55	.73	.84	.05	.57	.54	.53
Truck labor per acre (cost)			.11				.02						.013
Total labor cost per acre	$3.10	$3.63	$3.38	$7.31	$4.93	$1.06	$2.56	$2.67	$3.89	$.71	$1.14	$6.13	$3.30
Total labor cost per 1,000 trees	$61.87	$56.29	$55.28	$142.89	$75.99	$16.17	$33.11	$55.26	$59.58	$25.72	$22.10	$154.89	$56.65
Total labor cost per 1,000 mature trees equivalent	$135.19	$123.39	$209.83	$456.30	$169.41	$54.34	$88.82	$166.18	$217.67	$58.18	$56.12	$567.33	$154.96

*Based on area not cultivated and with assumed rates of pay of 40c per man hour, 20c per horse hour, 75c per truck hour and $1.50 per tractor hour.

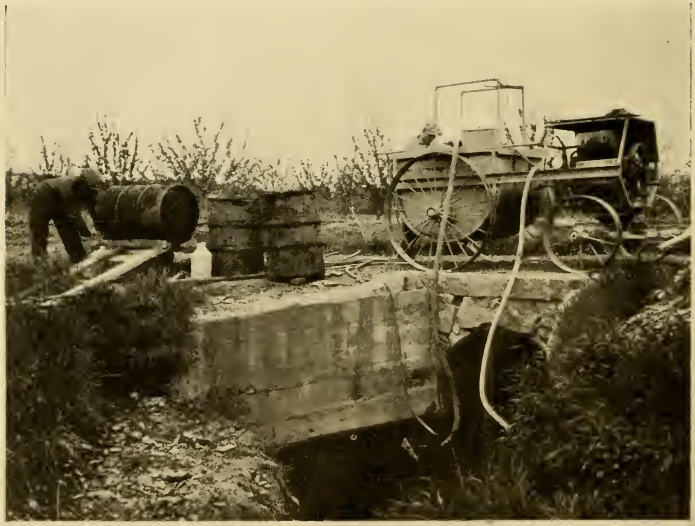
TABLE 18—*Annual man hours per acre used in soil management operations on orchards not cultivated.**

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Machine mowing	.85	1.47	1.76	1.78	1.18	.28	1.17	3.33	2.10	.22	1.4	1.38	1.32
Hand mowing	3.68	5.22	1.00	12.14	10.18	.14	3.52	1.43	5.52	1.38		9.80	4.39
Mulching	1.60	.76	3.14	2.57	.34	1.38	.60	.08		.04		2.78	1.20
Total	6.13	7.45	5.90	16.49	11.70	1.80	5.29	4.84	7.62	1.64	1.4	13.96	6.91

*Includes all orchards not cultivated whether mulched or not.

Horse and Tractor Labor

Culture and spraying are the only operations prior to harvest that make any considerable demand on power. Since the spraying comes at very brief periods in the spring, there is no conflict in horse requirements for the sod orchard. On most orchards, a team is required for spraying anyway, and the same horses can easily take care of mowing. Since in these orchards the proportion cultivated is small, no difficulty was encountered. If the whole orchard were tilled, the early spring tillage together with spraying and brush hauling would constitute a serious peak demand for power.



A little foresight and ingenuity have provided convenient sources of water in this orchard. The tank is quickly filled while the men measure out the spray material.

The cultivation, mowing and mulching represented over 36 per cent. of the total horse hours prior to harvest.

On the acre basis, an average of 6.2 hours horse labor, .22 hours tractor labor and .07 hours truck labor were employed per year (Table 12). With due allowances for substitution of tractor for horses, the farms cultivating a considerable portion of the orchard were greatly above the average, and those not cultivating were below the average.

At assumed rates per hour for man, horse and tractor, the approximate cost of soil management is shown in Table 14. These costs should be conceived of in a relative way as a rough method of reducing man, horse and tractor labor to common terms. On some farms

the time used had no very profitable competing opportunity; in other cases, it could have been put to profitable production on other crops.

The total cost of labor and power for cultural operations for all farms for three years was $4,645, or $5.34 per acre per year, $91 per 1,000 trees, or $264 per 1,000 mature tree equivalent. Farm 4 had the highest cost with $12.32 per acre, $294 per 1,000 trees and $633 per 1,000 mature trees. Farms 6, 10 and 11 did very little work on moisture control, and the cost per acre and per tree is low.

Whether or not the greater cost per acre is accompanied by greater average yields is difficult to determine. In general, it is thought that soil management has a very important bearing on yields, and that a reasonable amount of labor on this pays abundantly. Some with very low time requirement could probably put more effort in soil management, and perhaps a few have pushed the operation beyond the point of profitable returns.

On the basis of expected normal yield, the average cost was $44 per 1,000 boxes, with a range of $7 to $120. On the basis of actual yield, the average cost was $40 per 1,000 boxes, with a range of $14 to $104.

Cultivation

Of the twelve farms, four did considerable cultivating, having practically all of the orchard area under cultivation (Table 15). Farm 1 cultivated a block of bearing trees on very light land by merely disking. The type of soil tilled easily; and since the moisture problem was especially serious some years, the operator preferred to do this. Farm 2 tilled three small young non-bearing orchards by intercropping and plowed and tilled a mature orchard in 1927. Farm 3 tilled a block of non-bearing trees that had previously been in sod. Farm 4 tilled a large portion of orchard each year. The other farms had no large acreage in tillage.

There is some difference of opinion among fruit growers as to the effectiveness of the different methods, and any comparison between the cost of cultivation as opposed to sod mulch must be made with reservation. Tillage is frequently considered better than sod mulch, and yet on the other hand we have many examples of good tree growth and good yields where trees were grown and maintained from the beginning with sod mulch. There is not sufficient data available to determine the comparative yield over a period of years. If cultivated orchards yield more, do they yield enough more to pay for the extra cost?

Table 16 shows that the average quantity cost per acre for tillage was 23.4 man hours, 25.6 horse hours, 1.2 hours of tractor labor. Farm 1 with 17.6 hours per acre has light soil and can till its orchard without plowing. Farms 2 and 4 do a very careful and thorough job of tillage and intercrop a portion of the area. Farm 3 used a tractor, and did some of the tillage by means of a home-made, heavy oak, spike-tooth harrow. An average for the four farms of 399 hours of man labor, 427 horse hours, and 21 hours tractor labor was used per 1,000 actual trees. Farm 3 had a low man labor requirement of 190 hours per acre on account of tractor. Farm 4 had a high man labor requirement on

account of the thorough work done and of the fact that about one-quarter of this was for special work done on a small portion of one orchard.

At assumed rates for labor, the average cost of tillage was $16.36 per acre. Under present methods of cultivation, it is thought that $16 per acre can be taken as a fair average. Neither the number of trees per acre nor the age of the trees will have any large effect on the cost.

TABLE 19—*A comparison of cost of maintaining individual orchards under cultivation and under sod mulch.*

Non-bearing orchard on Farm No. 3	Cultivation Hours	Cultivation Cost	Sod Mulch Hours	Sod Mulch Cost
	1928		1926	
Man labor	152	$60.80	98	$39.20
Horse labor	54	10.80	18	3.60
Tractor	76.75	115.09		
Total	282.75	$186.69	116	$42.80
Per 1,000 trees		250.25		69.48
Per acre		13.28		3.57
Per 1,000 mature trees equivalent		4,445.00		256.00
Mature bearing orchards on Farm No. 2	1927		1928	
Man labor	209.25	$83.70	41.75	$16.70
Horse labor	396.5	79.30	33	6.60
Total		$163.00		$23.30
Per 1,000 trees		479.40		68.53
Per acre		13.58		1.94
Per 1,000 mature trees equivalent		522.10		74.70
3 Non-bearing orchards on Farm No. 2	3 years			
Man labor	675.25	$270.10		
Horse labor	809.25	161.85		
Total		$431.95		
Per 1,000 trees per year		168.20		
Per acre per year		15.57		
Per 1,000 mature trees		1,744.50		
Young bearing orchard on Farm No. 2			1928	
Man labor			45.5	$18.20
Horse labor			28	5.60
Total				$23.80
Per 1,000 trees				30.20
Per acre				2.03
Per 1,000 boxes, expected normal yield				8.96
Per 1,000 mature trees				66.48

While these costs represent the picture under present practices, it is possible that improved methods of cultivation might lower the cost considerably. But because many orchard sites have rough topography and rocky soil, tractors and speeial tools would not be practical and tillage in New England must remain high.

It is interesting to note here that the cultivation of very young orchards is expensive when considering the total weight of growth ex-

pected. The total vegetative growth made by an acre of year old trees is very small indeed. The operation of tillage would probably put as much linear growth on one 10-year old tree as on 20 trees at one year of age; and from this point of view, the tillage of an acre is twenty times as effective if applied to the older trees.

It would seem to be more economic to grow the tree under a heavy mulch system for ten years and then cultivate to incorporate organic matter. It may be possible to get along with less fertilizer in a cultivation program; but on the other hand, it is doubtful if much headway can be made in increasing content of organic matter without fertilizer. Then too, if there is any saving in fertilizer due to cultivation, the amount of saving would be larger when trees are older. From the point of view of organic matter, improvements made now for use ten years hence involve an expense in waiting. Might it not be better to reverse the usual procedure of cultivating the first ten years, and instead carry the trees along in mulch for this period and then cultivate occasionally to incorporate organic matter? Plowing under the thick sod formed by liberal use of nitrate of soda is one of the most efficient methods of adding organic matter to the soil.

When trees are very young, a small amount of mulch, 40 lbs. per tree, will be very effective. Later when trees are ten years old, three times as much mulch would be needed. Even with only 27 trees per acre and with liberal application of fertilizer, the mulch is likely to be inadequate when the tree is ten years old. At this age cultivation will control moisture and make it possible to reseed a new sod which will yield heavier mulch the next and succeeding years.

Occasionally other factors than moisture control may need consideration. In recently tilled fields, witch-grass may interfere with root growth and make some sort of cultivation or mechanical mulch necessary. Then, too, occasionally the vegetative growth becomes such a mat that the nitrate fertilizer applied does not get to the tree roots, being absorbed by the grass vegetation instead.

Inter-Tillage

Farms 2 and 4 did considerable inter-tillage in the young orchards; and in this case, the cost is somewhat complicated by joint production. When trees are set 108 to the acre there is ordinarily not mulch enough to get good tree growth; and if one is to have trees this thick, perhaps tillage is the best way. But when trees are so thick, it is doubtful if inter-tillage is practical. It is a case of choosing between having 5 acres of potatoes and beans and strawberries in the orchard, or taking another tract of 5 acres and putting these crops on it. The cost of the use of 5 acres of land is insignificant, and if the 5 acres is made more fertile by application of fertilizers and cultivation, this is as valuable to crops of beans, potatoes, etc., as it is to future crops of fruit. In other words, it is a doubtful practice to take the earnings from other crops and apply to the cost of growing apples when one has the option of putting these crops on other land under conditions where they could be produced more economically.

When an orchard is set out on land that is worth tilling, if the trees are set 27 to the acre and if there is a good amount of hay per acre,

then hay can be harvested perhaps on half the land for the first 10 years, or perhaps a crop can be grown to advantage. When more than 27 trees to the acre are planted, intercropping probably does not pay.

Sod-Mulch Orchards Not Cultivated

When the blocks not cultivated are segregated from the other blocks, the cost of soil management varies greatly on different farms, ranging from $.71 to $7.31 per acre (Table 17). This difference is accounted for in large part by differences in type of work done.

Farm 1 cuts a few swaths down through the orchard at a little less than an acre of orchard per hour, and then uses 3.7 hours of hand mowing (Table 18).

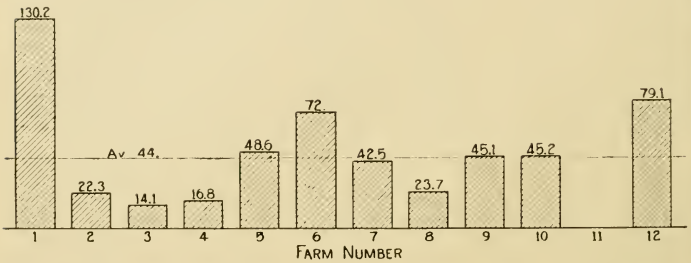


Fig. 11. *Man hours used in thinning per unit of 1,000 boxes actual yield* This chart indicates the variation in extent to which different growers consider thinning essential, and also, in part, differences in varieties. Farm 1 with many fairly mature Wealthy trees was obliged to thin to get marketable fruit. Conclusions as to efficiency in thinning cannot be drawn from this data.

On Orchard 2 with more trees per acre and thus with more difficult mowing, 1.5 hours machine mowing were used per acre, and then 5.2 hours of hand mowing were used in rather careful trimming around each tree.

Orchard 4 used 1.8 machine hours per acre and 12 to 14 hours in hand mowing. In this case, the whole orchard area is heavily fertilized, and grass growth is very vigorous, necessitating mowing twice each year.

Orchard 5 used 1.2 hours machine mowing per acre and 10.2 hours hand mowing. This large proportion of hand mowing was necessitated by rough rocky land.

On Orchard 7, 1.2 machine hours were used per acre and 3.5 hours hand mowing. On Orchard 8 some hand mowing was done when resting the horse while mowing with machine. Orchards 3 and 12 put considerable time on hauling and spreading mulch. About three hours per acre are accounted for in this way.

An average of all the farms was 1.3 hours for machine mowing, 4.4 hours for hand mowing and 1.2 hours for mulching—a total of 6.9 hours per acre. With assumed rates per hour, the total cost per acre was $3.30.

In several instances, labor records are available of the same block of trees under the sod mulch system and under cultivation (Table 19).

For instance, the non-bearing orchard on Farm 3 was cultivated in 1928 and was in sod in 1926. When reduced to the acre basis to allow for difference in size of block, the sod mulch cost was $3.57 per acre as compared to $13.28 for cultivation. On the 1,000 tree basis, the sod mulch cost $69 and cultivation $250.

Again in Orchard 2, a block of old trees was cultivated in 1927 and was in sod mulch in 1928. The acre cost was $13.58 and $1.94 respectively, or 47.9c and 6.8c per tree. On three small blocks of young trees in this orchard, inter-tillage with truck crops and strawberries was practiced. When the plowing and fitting of land was charged to the trees, the cost averaged $15.57 per acre or $168.20 per 1,000 trees. In a young bearing orchard on the same farm the mowing cost was $2.03 per acre, or $30.20 per 1,000 trees.

To sum up, tillage costs were about $16 per acre and sod mulch about $3.

THINNING

In years of heavy production, some thinning and propping is done on most farms, but there is little uniformity in the use of labor on thinning. Some of the operators are doubtful whether thinning pays but do a little on a few trees. Others hire extra help and make a general practice of going over the entire orchard. Farm 1 put on 956 hours per 1,000 tree units which is more than other orchards. In this case, 22 per cent. of the trees over 10 years are of the Wealthy variety, and these set so heavily with fruit that the operator finds it necessary to thin them every year. The other varieties are thinned in part. While the work was done in an otherwise slack time, so much thinning involved hiring three extra men for short periods. On Farm 7 about 18 per cent. of the bearing trees were Wealthy, and these and some other trees were thinned usually by the regular help. The average time in thinning was 290 hours per 1,000 mature tree units; 48 hours per 1,000 boxes normal yield; and 44 hours per 1,000 boxes actual yield (Table 20).

Mr. H. A. Rollins reports the results of thinning Baldwins on several farms as follows:[1]

YIELD IN POUNDS PER TREE

	Thinned	Not Thinned	Difference
Under 2¼	27	58	-31
2¼ to 2½	65	146	-81
2½ to 2¾	134	211	-77
2¾ to 3	153	164	-11
Over 3	119	103	+16
Total	498	682	-184

The thinned trees produced a higher per cent. of large apples, but the total yield was 184 pounds less. The quality was somewhat better on thinned trees.

[1]H. A. Rollins—The value of thinning Baldwin apples—Rpt. Am. Soc. Hort. Science 1930, p. 286.

Since thinning comes in July when requirements for other orchard work are negligible, thinning to make use of available labor is probably a good practice; but whether it pays to hire additional help is an unsolved problem. Those that have Wealthy trees feel that they must thin; but on other varieties, there is no agreement as to the best practice.

PROPPING

The propping operation included the hauling of props to the orchard in the early fall, propping up limbs, and then picking up the props and storing them after the crop was harvested. It did not take into account the cutting of props in the woods. In most cases the props had been cut and prepared previous to this study.

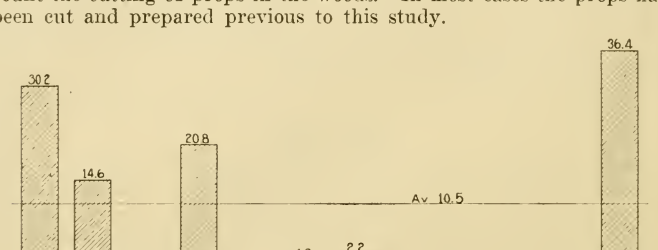


Fig. 12. *Man hours used in propping per unit of 1,000 boxes actual yield* Some growers believe that propping saves enough breakage to pay for the cost. Others do not. The work, if performed, can generally be fitted into periods when there is little other orchard work to do.

No doubt, trees that are weak and have bad crotches will need to be propped, but whether other trees need to be propped in a wholesale way is a question. If the tree is trained from the beginning by intelligent pruning, how much propping is necessary? Possibly trees that have been forced from the beginning by extra fertilizer need more propping than others. The significant point is that some do no propping and seem to have no particular trouble even in a year of heavy yields. Orchards 9 and 8 in 1927 with yields 2½ times the normal did no propping. These operators take the attitude that the loss of a limb, now and then, is of less consequence than the cost of propping. However, propping comes in the early fall at a slack period in orchard requirements.

On Farm 1, the trees had been pruned in the vase shape, following recommendations at the time, and on this account propping was important; 226 hours per 1,000 mature tree units, 30.2 hours per 1,000 boxes normal yield and 30.5 hours per 1,000 boxes actual yield were used (Table 20).

Farm 12 did about the same amount of propping. Farms 2 and 4 did a moderate amount. Farms 3, 5, 6 and 7 did very little. One man's slogan was: "If a limb isn't strong enough to hold apples, I'll grow one that will be."

SETTING TREES AND GRAFTING

In the three years, a total of 750 hours of man labor was used in setting, resetting or grafting trees. The resetting and grafting trees to replace damaged or dead trees was more or less of a miscellaneous job. A few orchardists made replacements, and one orchardist has each year done some grafting to work over trees not true to name. He spent in the three years 89 hours of man labor in correcting the mistake of some nurseryman. This is, of course, only a small part of the loss because production has been delayed. Since these trees are scattered through an orchard, we have no record on which to base an accurate estimate of the expense per tree of changing over to another variety.

Small new blocks were set out on four different farms in the three years: a total of 1,533 trees with 766 hours of man labor.

PROTECTION

Time on protecting orchards from mice and borers and similar pests accounted for 48 hours per 1,000 mature tree units and was highest on farms with a large proportion of trees under 15 years of age. Since very little time was consumed and since the work was not definite as to time, it is not a very important operation as regards labor requirement; but from the viewpoint of necessity in the program of orchard management, it is of great importance.

MISCELLANEOUS

There was a small amount of miscellaneous work in some orchards such as hauling off wormy apples, inspecting for partridge and deer damage or examining the growing fruit. In the three years, 1,662 hours of miscellaneous work on orchards before harvest were reported. This is approximately 5 per cent. of total time prior to harvest. On Orchards 4 and 6, which had the largest amount of miscellaneous work, slack time was used in cutting brush and leveling up parts of the orchards. In these instances, the time might have been charged to real estate improvement; but since the work would have no value except for orcharding, it was included under miscellaneous. On other farms, the time on miscellaneous work was very unimportant.

TOTAL COSTS PRIOR TO HARVEST

Man Hours

For all farms an average of 2,215 hours per 1,000 mature tree units was required prior to harvest (Table 20). The time requirement on individual farms varied greatly. Farms 1, 2, 4 and 12 used over 3,000 man hours; Farms 3, 5 and 9 between 2,000 and 3,000 man hours; Farms 6, 7 and 10 between 1,000 and 2,000 hours; and Farms 8 and 11 less than 1,000 hours per 1,000 mature tree units.

In general, the farms with high labor requirements had an intensive, and those with low labor requirements an extensive system. The total labor used per 1,000 mature tree units is to a considerable extent a measure of the degree of intensification. There are not sufficient data in three years to state decisively which is the more profitable system

TABLE 20—*Man hours prior to harvest by operations on twelve farms for three years.*

Per 1,000 mature tree units

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Pruning	555.8	1,111.1	539.0	460.0	528.5	308.8	402.0	72.6	505.	353.8	528.1	912.7	567.3
Spraying	577.0	573.9	408.8	628.5	380.4	163.9	215.0	138.5	670.	183.3	221.2	583.3	384.4
Brush disposal	179.0	332.2	208.9	341.0	284.2	74.2	76.6	18.0	82.	49.2	13.4	128.3	170.2
Fertilizing	46.7	91.0	133.0	101.3	98.3	56.1	56.8	52.6	115.	112.9	45.0	92.6	77.9
Cultivation	271.8	349.0	351.1	765.4	3.4	8.1	13.4						176.1
Mowing	150.6	175.9	121.8	521.3	391.3	27.3	156.6	319.6	427.	132.6	56.3	1,068.1	238.9
Mulching	53.3	20.1	138.7	96.2	11.9	90.4	20.0	5.3		3.0		265.9	50.2
Thinning	975.9	206.3	67.7	132.2	430.7	302.3	211.8	229.6	488.	186.4		431.9	289.8
Propping	226.4	135.3	2.1	164.5	3.0	5.6	10.9					199.1	68.9
Setting, resetting, grafting	29.7	9.1	259.7	65.3	20.0	42.8	8.9	29.3	60.			227.5	48.6
Protection	119.7	53.4	189.5	3.0	3.0	127.3	16.9					11.9	48.3
Miscellaneous	8.5	126.2	45.2	323.0	21.6	505.3	32.1	66.6	26.	3.8	8.4	29.1	94.4
Total prior to harvest	3,194.4	3,183.5	2,465.5	3,601.7	2,176.3	1,712.1	1,221.0	932.1	2,373.	1,025.0	872.4	3,950.4	2,215.0

Per 1,000 boxes expected yield

Pruning	75.0	186.5	106.3	75.6	86.8	51.3	69.3	14.1	97.0	58.2	75.9	165.9	94.9
Spraying	77.8	96.3	80.5	103.2	62.5	27.2	37.1	26.9	128.8	30.2	31.8	106.0	64.3
Brush disposal	24.2	55.7	41.2	56.0	46.8	12.3	13.2	3.5	15.7	8.1	1.9	23.3	28.5
Fertilizing	6.3	15.3	26.2	16.6	16.2	9.3	9.8	10.3	22.1	18.6	6.5	16.8	13.0
Cultivation	36.7	58.6	69.2	125.8	0.6	1.3	2.3						29.4
Mowing	20.3	29.5	24.0	85.6	64.4	4.5	27.0	62.2	82.0	21.8	8.1	194.1	40.0
Mulching	7.2	3.4	27.3	15.8	2.0	15.0	3.5	1.0		0.5		48.3	8.4
Thinning	131.7	34.6	13.3	21.7	70.8	50.3	36.6	44.7	93.8	30.7		78.5	48.5
Propping	30.5	22.7	0.4	27.0	0.5	0.9	1.9					36.2	11.5
Setting, resetting, grafting	4.0	1.5	51.2	10.7	3.3	7.1	1.5	5.7	11.5			41.3	8.1
Protection	16.1	9.0	37.3	0.5	0.5	21.1	2.9					2.2	8.1
Miscellaneous	1.1	21.2	8.9	53.1	3.6	83.8	5.5	12.9	5.1	0.6	1.2	5.3	15.8
Total prior to harvest	430.9	534.3	485.8	591.6	358.0	284.1	210.6	181.3	456.0	168.7	125.4	717.9	370.5

TABLE 20—*Man hours prior to harvest by operations on twelve farms for three years—continued.*

	Per 1,000 boxes actual yield												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
Pruning	74.1	119.9	112.1	58.3	59.6	73.6	80.7	7.5	46.6	85.9	156.4	167.2	86.1
Spraying	77.0	61.9	85.0	79.7	42.9	39.0	43.2	14.3	61.8	44.5	65.5	106.8	58.4
Brush disposal	23.9	35.8	43.4	43.2	32.0	17.7	15.4	1.8	7.5	12.0	4.0	23.5	25.8
Fertilizing	6.2	9.8	27.6	12.8	11.1	13.4	11.4	5.4	10.6	27.4	13.3	17.0	11.8
Cultivation	36.2	37.6	73.0	97.1	0.4	1.9	2.7						26.7
Mowing	20.1	19.0	25.3	66.1	44.1	6.5	31.4	33.0	39.4	32.2	16.7	195.6	36.3
Mulching	7.1	2.2	28.8	12.2	1.3	21.5	4.0	0.6		0.7		48.7	7.6
Thinning	130.2	22.3	14.1	16.9	48.7	72.0	42.5	23.8	45.2	45.2		79.1	44.0
Propping	30.2	14.6	0.4	20.8	0.3	1.3	2.2					36.4	10.5
Setting, resetting, grafting	4.0	1.0	54.1	8.3	2.2	10.2	1.8	3.1	5.5			41.7	7.4
Protection	16.0	5.8	39.5	0.4	0.3	30.3	3.4					2.2	7.3
Miscellaneous	1.1	13.6	9.4	41.0	2.4	120.5	6.4	6.9	2.5	1.0	2.6	5.3	14.3
Total prior to harvest	426.1	343.5	512.7	456.8	245.3	407.9	245.1	96.4	219.1	248.9	258.5	723.5	336.2

TABLE 21—*Horse, truck and tractor hours by operations per 1,000 mature trees used on twelve farms in caring for apple trees prior to harvest.*

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Spraying													
Horse	572.43	476.93	342.12	419.97	367.04	168.18	160.97	215.71	663.30	204.55	236.55	428.57	328.42
Truck							1.23				10.90		.78
Tractor													
Brush disposal													
Horse	162.42	166.78	151.19	171.81	144.44	48.48	51.00	17.98	81.70	43.18	9.92	42.33	101.21
Truck		3.04											.51
Tractor													
Fertilizing													
Horse	55.15	21.12	52.74	67.55	31.86	23.74	27.91	52.60	91.70	76.52	22.66		36.96
Truck		7.43	3.16			9.09							2.02
Tractor													
Tillage													
Horse	362.42	497.80	133.79	764.31		16.16							188.41
Truck			10.20				6.56						2.64
Tractor			112.34				6.46						10.86
Mowing													
Horse	56.36	77.39	147.33	133.63	40.78	36.36	78.20	239.68	235.00	18.18	112.52	220.24	95.83
Truck													
Tractor													
Mulching													
Horse	51.52	7.86	53.09			73.74	13.14	5.33		1.52		36.38	20.06
Truck			6.33				.82						.74
Tractor													
Protection													
Horse	37.58												3.52
Truck						.76							.04
Tractor													
Propping													
Horse	166.67	73.67		24.23			6.16					13.89	32.17
Truck				16.89									1.31
Tractor													
Miscellaneous													
Horse	4.85	19.94	19.69	30.10		8.08	6.98					15.87	10.79
Truck		1.35		5.87		3.03	.20	7.99				1.98	1.33
Tractor			7.03										.57
Total Prior to Harvest													
Horse	1,469.40	1,341.49	899.95	1,611.60	584.12	374.74	344.36	531.30	1,071.70	343.95	381.65	757.28	817.37
Truck		11.83	19.69	22.76		12.88	8.81	7.99			10.90	1.98	9.37
Tractor			119.37				6.46						11.43

to follow. It is felt, however, that above 3,000 hours is too intensive, and that below 1,000 hours may be too extensive. The men with over 3,000 hours have been very successful but might have been more successful under a more conservative system. Some with low time requirement have been very successful.

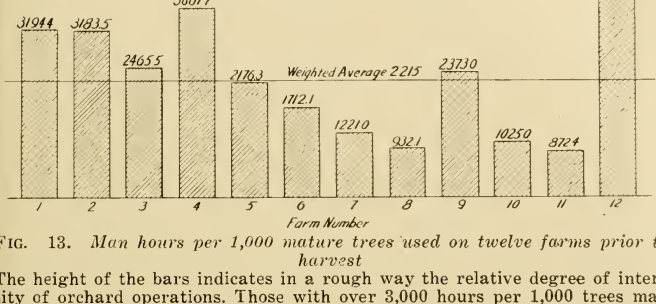


FIG. 13. *Man hours per 1,000 mature trees used on twelve farms prior to harvest*

The height of the bars indicates in a rough way the relative degree of intensity of orchard operations. Those with over 3,000 hours per 1,000 trees may be said to follow intensive methods; those with under 2,000 hours, extensive methods.

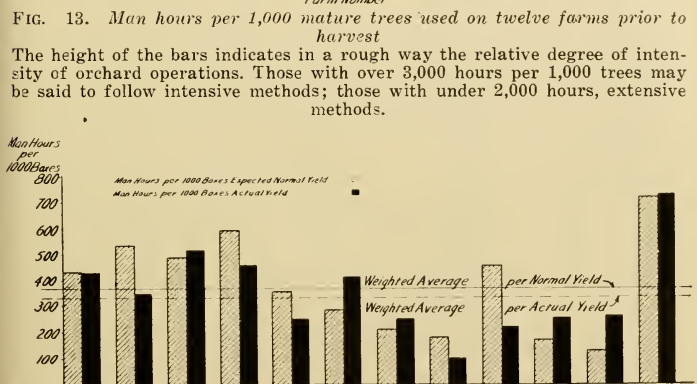


FIG. 14. *Man hours prior to harvest required to produce 1,000 boxes of apples, expected and actual yields*[1]

The shaded area indicates the hours of man labor when computed on the basis of 1,000 boxes expected yield. The black area indicates the hours of man labor when computed on a basis of actual yields. Like the previous figure, the shaded area is a rough indication of intensity of orchard operations. A comparison of black area with shaded gives some indication of the effect of yield on man labor cost. Farm 8 with extensive methods and good yields used only 96.4 hours per 1,000 boxes actual yield.

When computed on the basis of expected normal yield, the average man labor requirement was 370 hours per 1,000 boxes. Farms 2, 4 and 12 had over 500 hours per 1,000 boxes; Farms 1, 3 and 9 between 400

[1]Without taking into consideration appreciation or depreciation in value of trees.

TABLE 22—*Cost of horse, truck and tractor prior to harvest by operations on twelve farms for three years. Assumed rates of 20c per horse hour, 75c per truck hour and $1.50 per tractor hour.*

Per 1,000 mature tree units

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Spraying	$114.49	$95.39	$68.42	$83.99	$73.41	$33.64	$33.12	$43.14	$132.67	$40.91	$55.15	$85.71	$66.28
Brush disposal	32.49	35.64	30.24	34.37	28.88	9.70	10.20	3.60	16.33	8.64	1.97	8.46	20.63
Fertilizing	11.03	9.80	12.92	13.51	6.37	11.56	5.58	10.52	18.33	15.30	4.50		8.90
Tillage	72.48	99.56	202.93	152.87	8.16	3.23	14.62						55.96
Mowing	11.27	15.48	29.46	26.72		7.27	15.64	47.94	47.00	3.64	22.50	45.05	19.17
Mulching	10.30	1.57	15.36			14.75	3.24	1.06		.30		7.28	4.56
Protection	7.52					.56							.74
Propping	33.33	14.73		17.51			1.23					2.78	7.41
Miscellaneous	.97	5.00	14.49	10.42		3.89	1.55	5.99				4.66	4.01
Total prior to harvest	$293.88	$277.17	$373.82	$339.39	$116.82	$84.60	$85.18	$112.25	$214.33	$68.79	$84.12	$152.94	$187.66

Per 1,000 boxes expected yield

Spraying	$15.45	$16.01	$13.48	$13.80	$12.08	$5.58	$5.72	$8.39	$25.50	$6.73	$7.92	$15.58	$11.09
Brush disposal	4.38	5.98	5.96	5.64	4.75	1.61	1.76	.70	3.14	1.42	.28	1.54	3.45
Fertilizing	1.49	1.64	2.55	2.22	1.05	1.92	.96	2.04	3.52	2.52	.65		1.49
Tillage	9.78	16.71	39.99	25.11	1.34	.54	2.52						9.36
Mowing	1.52	2.60	5.81	4.39		1.20	2.70	9.33	9.03	.60	3.23	8.00	3.21
Mulching	1.39	.26	3.03			2.45	.56	.21		.05		1.32	.76
Protection	1.01					.09							.12
Propping	4.50	2.47		2.88			.21					.50	1.24
Miscellaneous	.13	.84	2.85	1.71		.64	.27	1.16				.85	.67
Total prior to harvest	$39.65	$46.51	$73.67	$55.75	$19.22	$14.03	$14.70	$21.83	$41.19	$11.32	$12.08	$27.79	$31.39

TABLE 22—*Cost of horse, truck and tractor prior to harvest by operations on twelve farms for three years. Assumed rates of 20c per horse hour, 75c per truck hour and $1.50 per tractor hour—continued.*

	Per 1,000 boxes actual yield												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
Spraying	$15.27	$10.30	$14.22	$10.65	$8.28	$8.01	$6.65	$4.46	$12.24	$9.93	$16.34	$15.70	$10.06
Brush disposal	4.33	3.84	6.29	4.36	3.26	2.31	2.05	.37	1.51	2.10	.58	1.55	3.13
Fertilizing	1.47	1.06	2.69	1.72	.71	2.76	1.12	1.08	1.69	3.72	1.33		1.35
Tillage	9.68	10.74	42.19	19.38	.92	.77	2.94						8.50
Mowing	1.50	1.67	6.13	3.39		1.73	3.14	4.96	4.34	.88	6.67	8.07	2.91
Mulching	1.37	.17	3.20			3.51	.65	.11		.07		1.33	.69
Protection	1.00					.13							.11
Propping	4.45	1.59		2.22			.25					.51	1.12
Miscellaneous	.13	.54	3.01	1.32		.94	.30	.62				.85	.61
Total prior to harvest	$39.20	$29.91	$77.73	$43.04	$13.17	$20.16	$17.10	$11.60	$19.78	$16.70	$24.92	$28.01	$28.48

TABLE 23—*Operating cost on twelve farms prior to harvest by factors. Not including land or overhead charges. Based on assumed rates of 40c per man hour, 20c per horse hour, 75c per truck hour and $1.50 per tractor hour.*

Per 1,000 mature tree units

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Man hours	$1,277.76	$1,273.40	$986.20	$1,440.68	$870.52	$684.84	$488.40	$372 84	$949.20	$410.00	$348.96	$1,580.16	$886.00
Horse hours	293.88	277.17	373.82	339.39	116.82	84.60	85.18	112.25	214.33	68.79	84.12	152.94	187.66
Fertilizer	251.88	475.08	500.69	1,897.93	383.67	256.56	332.50	308.92	580.83	483.33	478.20	390.21	499.42
Spray materials	329.53	581.27	346.27	306.47	176.25	81.56	706.06	240.51	336.00	153.39	121.97	443.12	436.40
Use of spray machines	64.23	183.48	84.99	261.92	122.67	52.17	48.79	117.22	83.33	167.06	110.91	297.25	118.52
Total	$2,208.28	$2,790.40	$2,291.97	$4,246.39	$1,669.93	$1,159.73	$1,660.93	$1,151.74	$2,163.69	$1,282.57	$1,144.16	$2,863.68	$2,128.00

Per 1,000 boxes expected yield

Man hours	$172.36	$213.72	$194.32	$236.64	$143.20	$113.64	$84.24	$72.52	$182.40	$67.48	$46.16	$287.16	$148.22
Horse hours	39.65	46.51	73.67	55.75	19.22	14.04	14.70	21.82	41.19	11.32	16.08	27.79	31.39
Fertilizer	33.98	79.72	97.28	311.78	63.12	42.56	57.38	60.07	111.63	79.57	68.70	70.91	83.54
Spray materials	43.25	97.54	67.28	50.34	29.00	13.53	121.84	46.77	64.57	25.25	17.52	80.53	72.99
Use of spray machines	8.66	30.79	16.75	43.03	20.18	8.65	8.42	22.79	16.02	27.50	15.93	54.02	19.83
Total	$297.90	$468.28	$449.30	$697.54	$274.72	$192.42	$286.58	$223.97	$415.81	$211.12	$164.39	$520.41	$355.97

Per 1,000 boxes actual yield

Man hours	$170.43	$137.40	$205.08	$182.72	$98.12	$163.16	$98.04	$38.56	$87.64	$99.56	$103.40	$289.40	$134.48
Horse hours	39.20	29.91	77.73	43.04	13.17	20.16	17.10	11.60	19.78	16.70	24.92	28.01	28.48
Fertilizer	33.60	51.27	102.66	240.69	43.25	61.13	66.74	31.93	53.61	117.37	141.67	71.46	75.81
Spray materials	42.75	62.73	71.00	38.86	19.87	19.43	141.73	24.86	31.02	37.25	36.13	81.15	66.24
Use of spray machines	8.56	19.80	17.67	33.22	13.82	12.43	9.79	12.12	7.69	40.57	32.86	54.44	17.99
Total	$294.54	$301.11	$474.14	$538.53	$188.23	$276.31	$333.40	$119.07	$199.74	$311.45	$338.98	$524.46	$323.00

and 500 man hours; Farms 5, 6 and 7 between 200 and 400 hours; and Farms 8, 10 and 11 less than 200 man hours per 1,000 boxes.

When computed on the basis of the actual yields, the average man labor requirement was 336 man hours per 1,000 boxes. Farms 3 and 12 used over 500 hours per 1,000 boxes; Farms 1, 4 and 6 between 400 and 500 hours; Farms 2, 5, 7, 9, 10 and 11 between 200 and 400 hours; and Farm 8 under 100 hours. Farm 8 did little work per mature tree, and on account of very high yield in 1927 had a very low average man labor requirement per box of apples.

Horse Hours

For all farms, an average of 817 horse hours, 9.37 truck hours and 11.43 tractor hours per 1,000 mature trees equivalent was required prior to harvest.

Farms 1, 2 and 4 had over 1,000 horse hours per 1,000 mature trees. Farm 3 would be in this group if it had not substituted tractor power for horses in cultivation. Farms 5, 8 and 12 used between 500 and 1,000 horse hours per 1,000 mature trees. Farms 6, 7, 9, 10 and 11 used less than 400 horse hours per mature tree.

Tractor power to the extent of 119.4 hours per 1,000 mature trees was used on Farm 3. Seven farms used the truck for incidental jobs.

In general, the farms that put on several sprays and did some tillage had high horse cost per 1,000 trees.

When computed on basis of expected normal yields, an average of 137 horse hours per 1,000 boxes was required. Farms 2, 4 and 9 used over 200 hours; Farms 1, 3, 8 and 12 between 100 and 200 hours; and Farms 5, 7, 10 and 11 less than 100 horse hours per 1,000 bushels. An average of 1.6 tractor hours and 1.9 truck hours was used in addition to horse labor.

When computed on basis of actual yields an average of 123.4 horse hours was required per 1,000 boxes. In this case, only Farm 4 had over 200 hours per 1,000 boxes. Farms 1, 2, 3, 11 and 12 used between 100 and 200 horse hours, and Farms 5, 6, 7, 8, 9 and 10 used less than 100 horse hours per 1,000 boxes. The peak of horse labor requirements is the short but difficult spray periods. The number of horses needed on a fruit farm under sod mulch is largely determined by the spray program.

Money Costs

The only way to sum up the different quantity costs of growing fruit seems to be in terms of money. It is well, however, to realize that, in reducing to a money cost, the results are artificial and should be used simply as a criterion to study the differences between orchards. In the first place, the rate of pay of the operator and the hired men must be assumed. The owner-operator does not work for wages; and while the hired man does, the time is somewhat diffused by slack periods and by unfavorable weather. On some of the farms, other productive labor can be found for the regular men when orchard work is slack; on other farms, orcharding is the only enterprise.

Notwithstanding this, we have assumed for purposes of comparison the same rates per man hour for all orchard work. This, of course,

TABLE 24—*Operating cost prior to harvest by operations. Land and overhead charges not included. Based on assumed rate of 40c per hour for man labor, 20c per horse hour, 75c per truck hour and $1.50 per tractor hour.*

Per 1,000 mature tree units

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Pruning	$222.32	$444.44	$215.60	$184.00	$211.40	$123.52	$160.80	$29.04	$202.00	$141.52	$211.24	$365.08	$226.92
Spraying	730.04	1,089.70	663.20	903.78	524.49	232.93	873.97	456.27	820.00	434.68	376.51	1,059.40	774.96
Brush disposal	104.09	168.52	113.80	170.76	142.57	39.38	40.84	10.80	49.13	28.32	7.33	59.78	88.71
Fertilizing	281.59	521.28	566.81	1,951.96	429.36	290.56	360.80	340.48	645.16	543.79	500.70	427.25	539.48
Cultivation	181.29	239.16	343.37	459.02	9.52	6.47	19.98						126.40
Mowing	71.51	83.84	78.18	235.24	156.52	18.19	78.28	175.78	217.80	56.68	45.02	471.29	114.73
Mulching	31.62	9.61	70.84	38.48	4.76	50.91	11.24	3.18		1.50		113.64	24.64
Thinning	390.36	82.52	27.08	52.88	172.32	120.92	84.72	91.84	195.20	74.56		172.76	115.92
Propping	123.89	68.85	.84	83.31	1.20	2.24	5.59					82.42	34.97
Setting	11.88	3.64	103.88	26.12	8.00	17.12	3.56	11.72	24.00			91.00	19.44
Protection	55.40	21.36	75.80	1.16	1.20	51.48	6.76					4.76	20.06
Miscellaneous	4.37	55.48	32.57	139.62	8.68	206.01	14.39	32.63	10.40	1.52	3.36	16.30	41.77
Total	$2,208.27	$2,790.40	$2,291.97	$4,246.33	$1,670.02	$1,159.73	$1,660.93	$1,151.74	$2,163.69	$1,282.57	$1,144.16	$2,863.68	$2,128.00

Per 1,000 boxes expected yield

Pruning	$30.00	$74.60	$42.52	$30.24	$34.72	$20.52	$27.72	$5.64	$38.80	$23.28	$30.36	$66.36	$37.96
Spraying	98.48	182.86	129.71	148.45	86.26	38.64	150.82	88.71	157.61	71.56	54.09	192.53	129.63
Brush disposal	14.06	28.26	22.44	28.04	23.47	6.53	7.04	2.10	9.42	4.66	1.04	10.86	14.84
Fertilizing	37.99	87.48	110.31	320.64	70.65	48.20	62.26	66.23	123.99	89.53	71.95	77.63	90.24
Cultivation	24.46	40.15	67.67	75.43	1.58	1.06	3.44						21.14
Mowing	9.64	14.40	15.41	38.63	25.76	3.01	13.50	34.20	41.83	9.32	6.47	85.64	19.21
Mulching	4.27	1.62	13.95	6.32	.80	8.45	1.96	.61		.25		20.64	4.12
Thinning	52.68	13.84	5.32	8.68	28.32	20.12	14.64	17.88	37.52	12.28		31.40	19.39
Propping	16.70	11.55	.16	13.68	.20	.36	.97					14.98	5.85
Setting	1.60	.60	20.48	4.28	1.32	2.84	.60	2.28	4.60			16.52	3.25
Protection	7.45	3.60	14.92	.20	.20	8.53	1.16					.88	3.35
Miscellaneous	.57	9.32	6.41	22.95	1.44	34.16	2.47	6.32	2.04	.24	.48	2.97	6.99
Total	$297.90	$468.28	$449.30	$697.54	$274.72	$192.42	$286.58	$223.97	$415.81	$211.12	$164.39	$520.41	$355.97

TABLE 24—*Operating cost prior to harvest by operations. Land and overhead charges not included. Based on assumed rate of 40c per hour for man labor, 20c per horse hour, 75c per truck hour and $1.50 per tractor hour—continued.*

	Per 1,000 boxes actual yield												
Pruning	$29.64	$47.96	$44.84	$23.32	$23.84	$29.44	$32.28	$3.00	$18.64	$34.36	$62.56	$66.88	$34.44
Spraying	97.38	117.59	136.90	114.61	59.13	55.47	175.45	47.16	75.67	105.55	111.53	194.01	117.65
Brush disposal	13.89	18.16	23.65	21.64	16.06	9.39	8.21	1.09	4.51	6.90	2.18	10.95	13.45
Fertilizing	37.55	56.25	116.39	247.53	48.40	69.25	72.42	35.17	59.54	132.05	148.32	78.26	81.88
Cultivation	24.15	25.78	71.39	58.22	1.08	1.53	4.02						19.18
Mowing	9.54	9.27	16.25	29.83	17.64	4.33	15.70	18.16	20.10	13.76	13.35	86.31	17.43
Mulching	4.21	1.05	14.72	4.88	.52	12.11	2.25	.35		.35		20.81	3.73
Thinning	52.08	8.92	5.64	6.76	19.48	28.80	17.00	9.52	18.08	18.08		31.64	17.60
Propping	16.53	7.43	.16	10.54	.12	.52	1.13					15.07	5.32
Setting	1.60	.40	21.64	3.32	.88	4.08	.72	1.24	2.20			16.68	2.96
Protection	7.40	2.32	15.80	.16	.12	12.25	1.36					.88	3.03
Miscellaneous	.57	5.98	6.77	17.72	.96	49.15	2.86	3.38	1.00	.40	1.04	2.97	6.33
Total	$294.54	$301.11	$474.15	$538.53	$188.23	$276.32	$333.40	$119.07	$199.74	$311.45	$338.98	$524.46	$323.00

takes for granted that the time not on orchard work can either be used profitably or that help is available on call for short periods. In making comparisons on different farms, certain management problems involving the use of regular men on orchard tasks in slack seasons need to be studied from other than an enterprise method and will be touched on in the second publication of this series in dealing with farm organization.

Operating cost as considered here includes only the cost of man labor, horse, truck and tractor labor, spray material, fertilizer and use of spray machine. Land, interest and taxes are not included. The average cost per 1,000 mature tree units was $2,128 a year (Table 23). This is made up of $886 or 42 per cent. man labor; $188 or 9 per cent. horse labor; $500 or 24 per cent. fertilizer; $436 or 20 per cent. spray materials; $118 or 6 per cent. use of spray machine. The operating cost varies greatly. Farm 4 is highest with $4,246 per 1,000 mature tree units (Table 23). Farms 1, 2, 3, 9 and 12 have costs between $2,000 and $3,000, and Farms 5, 6, 7, 8, 10 and 11 between $1,000 and $2,000. The extreme high cost of No. 4 is largely due to very high cost of fertilizer.

When computed on a basis of normal expected yields (Table 23), the average cost was $356 per 1,000 boxes. Farms 2, 3, 4, 9 and 12 had costs over $400 per 1,000 boxes; Farms 1, 2, 7, 8 and 10 had between $200 and $300; and Nos. 6 and 11 had costs less than $200.

When computed on basis of actual yields, the average cost was $323 per 1,000 boxes. Farms 3, 4 and 12 had costs over $400; Farms 1, 2, 6, 7, 10 and 11 had costs between $200 and $400; Farms 5, 8 and 9 had costs below $200. Farm 8 was lowest with only $120 per 1,000 boxes actual yield and No. 4 was highest with $539.

Table 25—*Comparison of operating costs between twelve farms and twenty-six additional farms (land and orchard not included).*

	Per 1,000 trees		Per 1,000 boxes expected yield	
	12	26	12	26
Man labor	$886.00	$761.75	$148.22	$124.44
Horse, truck and tractor	187.66	186.96	31.39	32.88
Fertilizer	499.42	528.04	83.54	86.42
Spray material	436.40	187.47	72.99	30.64
Use of sprayer	118.52	170.25	19.83	27.81
Total	$2,128.00	$1,834.47	$355.97	$302.19

Comparison of the 12 Farms and 26 Other Farms

For comparative purposes a survey was made on 26 additional fruit farms scattered in different parts of the state. A comparison of the records of these 26 farms with the detail records in this study show few distinct differences in the average man labor requirements. The 26 farms did practically no cultivating and only about half as much thinning.

On the 12 farms, 29 man hours were used in cultivation per 1,000 boxes normal yield, and on the 26 farms only 3 hours were so used

TABLE 26—*Comparison between twelve fruit farms on route and twenty-six additional farms by survey method.*

	Man hours				Operating costs of materials and labor at assumed rates			
	Per 1,000 bushels		Per 1,000 mature trees		Per 1,000 bushels		Per 1,000 mature trees	
	12	26	12	26	12	26	12	26
Pruning	95.	104.5	567	659.8	$37.96	$41.80	$226.92	$255.82
Spraying	64.	72.1	384	455.2	129.63	100.83	774.96	617.11
Brush disposal	29.	20.4	170	128.8	14.84	14.88	88.71	79.08
Fertilizing	13.	11.6	78	73.5	90.24	94.95	539.48	580.54
Cultivation	29.	3.	176	18.7	21.14	2.62	126.40	22.54
Mowing	40.	51.4	239	324.3	19.21	25.75	114.73	157.42
Mulching	8.	6.5	50	40.9	4.12	4.49	24.64	24.71
Thinning	49.	19.3	290	122.	19.39	7.72	115.92	47.31
Propping	11.	10.5	70	65.3	5.85	4.60	34.97	31.95
Setting	8.1		49		3.25		19.44	
Protection	8.1	3.4	48	21.4	3.35	1.36	20.06	8.28
Miscellaneous	15.8	8.7	94	54.7	6.99	3.88	41.77	23.63
Total	370.	311.2	2,215	1,964.6	$355.97	$302.88	$2,128.00	$1,848.39

TABLE 27—*Correlation between operating costs of growing apples up to harvest and yields.*

Farm No.	1926 % of Yield	Cost	1927 % of Yield	Cost	1928 % of Yield	Cost	Average % of Yield	Average Cost
1	103	$293.65	92	$286.26	108	$301.43	101	$294.48
2	194	242.86	105	421.93	170	287.77	155	301.16
3	59	812.28	94	407.72	123	391.42	95	474.15
4	124	653.18	149	470.70	117	520.70	129.5	538.66
5	119	251.70	172	149.74	144	187.24	146	188.21
6	63	300.57	76	256.46			70	276.33
7	95	304.73	111	283.72	58	448.40	86	333.40
8	107	221.47	257	82.71			188	119.06
9	134	289.04	268	163.78			208	199.74
10	49	466.58	105	224.89	49	347.96	68	311.44
11			51	285.08	46	392.83	48	338.95
12			84	578.09	113	486.89	99	524.45
Average		$327.98		$291.85		$356.37		$323.04

(Table 26). In thinning, 49 man hours were used on the 12 farms and 19 man hours on the 26 farms per 1,000 boxes. This is accounted for by the larger proportion of Wealthy apple trees. In total time requirement, the 12 farms were higher with 370 hours as compared to 311 hours. The 12 farms had 2,215 man hours per 1,000 mature trees as compared to 1,965 for the 26 farms. Spraying costs were somewhat higher on the 12 special farms.

The total operating costs were $356 on the 12 farms as compared to $303 on the 26 farms per 1,000 boxes normal yield, and they were $2,128 on the 12 farms as compared to $1,848 on the 26 farms per 1,000 mature tree units. It would seem from this comparison, however, that the 12 farms were not materially different from the larger sample.

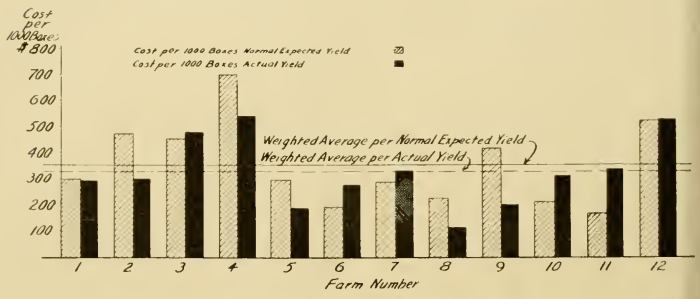


Fig. 15. *Operating costs in producing apples on twelve farms*
In estimating cost, expense of man labor was assumed at 40c per hour, horse labor at 20c, truck hours at 75c and tractor hours at $1.50. The shaded area indicates the relative cost if yields followed the curve in Fig. 2. The black area indicates the relative costs when based on actual yields.

Appreciation and Depreciation

Up to this point, little mention has been made of the appreciation or depreciation of trees and the effect of this on the cost of growing fruit in the various orchards. The subject of the value of fruit trees is to be considered in detail in a later publication. At this time it suffices to say that with efficient management if yields follow the curve shown in Figure 2, the maximum value of a tree based on anticipated profits will come at about 19 to 20 years of age. Values appreciate gradually up to this time and depreciate afterward. Using a scale based fundamentally on this conception the orchards varied greatly in inventory change in tree values. Orchard 1 with the great bulk of its trees just passing the period of highest value had an inventory loss in tree value of $562 in three years. Orchard 3 with many young trees had an inventory gain of $3,488. For all orchards for all years, there was a gain of $8,114. This inventory change must be considered in discussing the costs.

Other Costs

Land value was taken at approximately that for purposes other than orchard and varied from $30 to $80 per acre. For use of land 5 per cent. was estimated for interest and 2½ per cent. for tax on land. Interest was figured at 5 per cent. on value of the trees and tax on trees was put in at 1¼ per cent. Since the value of the trees results partly from the value of apples, it would be reasoning in a circle to use this figure in determining the cost of producing fruit. But with the value of tree assumed as explained briefly above and with assumed rates per hour for labor, the costs of producing apples as shown in Table 28 can be used in studying the relative situation on the different farms; and if we have the assumptions in mind, the average cost of producing apples will be reasonably accurate.

Total Net Cost

With these assumptions, the total cost prior to harvest on all farms for all three years was $62,180 (Table 28). Of this amount, 6.6 per

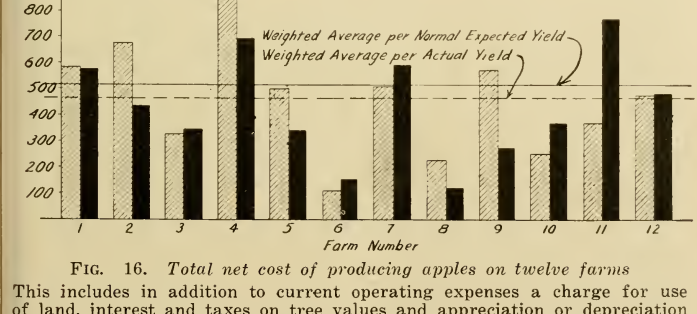


FIG. 16. *Total net cost of producing apples on twelve farms*
This includes in addition to current operating expenses a charge for use of land, interest and taxes on tree values and appreciation or depreciation in value of trees. Farm 6, producing Baldwins only by extensive methods, and Farm 8, by a combination of extensive methods and high yields of McIntosh, had lowest costs.

cent. was for use of land, 33.6 per cent. for use of trees and 60.3 per cent. for current operating expenses. But since there should be a credit of $8,114 for tree growth, the net cost of producing apples was only $54,066 which is $514 per 1,000 boxes normal expected yield and $466 per 1,000 boxes actual yield.

In cases of joint cost such as this, it is probably more correct to state that an estimated expense of $62,180 resulted in the production of 116,000 boxes of apples and also tree growth estimated at over $8,000 in value.

Since, however, the major interest in this problem at this point is in fruit production and since apples are the final product, it is perhaps practical to divide the costs by allocating to tree growth a sum

equivalent to increase in inventory of trees. So in each case in this study, the appreciation or depreciation of trees was added to or subtracted from the cost of production, and the comparison in Table 28 is on that basis.

Since the credit for growth of trees represents about 13 per cent. of the total expense, it might be roughly estimated that 87 per cent. of the expense went for apple production and 13 per cent. for growth of trees. When this rather rough way of dividing production of apples and production of tree is made, the situation between the different orchards is made more comparable when considering costs, on a basis of normal or actual yields. For instance, in the case of Farm 3, about 60 per cent. of the energy has gone into the tree and only 40 per cent. into production of apples.

When the total cost of producing apples is computed according to normal expected yield, the costs vary from $107 on Farm 6 to $894 on Farm 4 per 1,000 boxes. Five farms had costs over $500, four between $300 and $500, and three below $300 per 1,000 boxes.

In the same way, when computed on basis of actual yields, the range is from $121 per 1,000 boxes to $770 per 1,000 boxes. Four farms have costs above $500, five farms have costs between $300 and $500, and three have costs below $200. The two low-cost producers have been credited with rather large amounts for increase in value of trees. Since these particular men were producing the trees economically, any margins in their costs of production and the value as shown in inventory tend to lower the cost. In the case of Farm 8, an expense of $1,909 produced 7,265 boxes of apples, and also tree growth valued at over $1,000. If one credits the tree growth to the cost of producing apples, the apples cost about $228 per 1,000 boxes; but if the value of the apples were credited to the cost of growing more trees, the trees were produced for nothing.

No doubt some part of the miscellaneous overhead should be charged against the production of apples up to harvest. On seven farms, the total time on miscellaneous work was about equal to the total time on apple orchards up to harvest. But since we are using these costs merely for comparison in study of management problems, it would be very artificial to attempt to allocate the overhead. This part of the problem will receive further consideration in later publications on farm orchard organization.

HARVESTING APPLES

On all farms, an average of 358 hours per 1,000 boxes actual yield was required in harvesting.

On three farms, Nos. 5, 10 and 12, over 400 man hours were required to harvest 1,000 boxes. On eight farms between 300 and 400 hours were needed. On one farm—No. 1—less than 300 man hours per 1,000 boxes were used (Table 29).

This includes both picking and in most cases hauling to the barn. Certain lots of apples were hauled direct from the orchard by purchaser. There was considerable difference between years on the same farm, due probably to the differences in the crop. For the large crop

TABLE 28—*Net cost of producing apples on twelve farms.*

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Use of land	$482.40	$723.60	$561.60	$486.00	$121.50	$195.00	$749.25	$189.00	$100.80	$163.80	$126.00	$216.60	$4,115.55
Interest on value of trees	1,961.47	2,519.70	1,632.44	1,153.33	954.15	795.51	4,342.39	684.20	312.62	585.56	716.53	816.50	16,474.40
Operating cost	3,643.66	8,256.84	3,242.24	5,783.61	1,965.51	1,148.16	8,092.35	864.95	649.15	846.50	813.49	2,164.94	37,471.40
Estimated tax on trees	490.37	629.92	408.11	288.33	238.54	198.88	1,085.60	171.05	78.16	146.39	179.13	204.12	4,118.60
Total	6,577.90	12,130.06	5,844.39	7,711.27	3,279.70	2,337.55	14,269.59	1,909.20	1,140.73	1,742,25	1,835.15	3,402.16	62,179.95
Gain or loss-inventory	-561.90	194.15	3,487.85	295.35	-291.45	1,696.75	-111.16	1,028.40	247.35	730.95	-13.60	1,411.35	8,114.04
Net cost	7,139.80	11,935.91	2,356.54	7,415.92	3,571.15	640.80	14,380.75	880.80	893.38	1,011.30	1,848.75	1,990.81	54,065.91
Net cost per 1,000 boxes actual yield	577.04	435.35	344.62	690.69	341.96	154.22	592.48	121.24	274.89	372.08	770.31	482.27	466.10
Net cost per 1,000 boxes normal expected yield	583.60	676.94	326.57	894.45	499.18	107.37	509.41	228.07	572.31	252.26	373.56	478.56	513.61

TABLE 29—*Cost of harvesting apples.*

	1	2	3	4	5	6	7	8	9	10	11	12	
Man hours total	3,576	10,669½	2,565½	3,715	4,545	1,337½	7,836¾	2,415	1,175¼	1,281	722½	1,652	41,491
Horse hours total	1,012	193¼	29½	9	418½		165½		205	126½	1		2,160¼
Truck hours total		764¾	73½	14	39	1	620½				20½	9	1,542¼
Man hours per 1,000 boxes	289.2	389.2	375.2	346.0	435.2	321.9	322.9	332.4	361.6	471.3	301.0	400.2	357.7
Horse hours per 1,000 boxes	81.8	7.0	4.3	.8	40.1		6.8		63.1	46.5	.4		18.6
Truck hours per 1,000 boxes		27.9	10.7	1.3	3.7	.2	25.6				8.5	2.2	13.3
Cost man hours per 1,000 boxes	$115.68	$155.68	$150.08	$138.40	$174.08	$128.76	$129.16	$132.96	$144.64	$188.52	$120.40	$160.08	$143.08
Cost horse hours per 1,000 boxes	16.36	1.40	.86	.16	8.02		1.36		12.62	9.30	.08		3.72
Cost truck hours per 1,000 boxes		20.92	8.02	.98	2.78	.15	19.20				6.38	1.65	9.98
Total cost per 1,000 boxes	132.04	178.00	158.96	139.54	184.88	128.91	149.72	132.96	157.26	197.82	126.86	161.73	156.78

of 1927, the requirements were 320 hours per 1,000 boxes as compared to 380 for the other two years.

Farm 8 was hit with hail in 1926, and the crop was small. The next year the crop was heavy and the apples were large in size. The labor requirement dropped from 510 hours to 270 hours per 1,000 boxes. Farm 2 hired from 15 to 25 men, mostly transients, for picking. One of the regular crew was used as a picking foreman and did very little picking himself. There was no particular check on the individual pickers. More emphasis was put on careful handling of fruit than on amount picked.

The apples were hauled to the storage barn by means of an old truck. About 16 boxes could be loaded from the ground. The young man who ran this made regular trips, hauling out empty boxes to the orchard and hauling in 16 boxes of apples at the rate of about four trips per hour. An average of approximately 390 hours was required in harvesting 1,000 boxes.

In the case of Farm 1 the crew consisted of the farm operator and six to seven men working together. The apples were dumped in barrels, which were set on a low platform wagon, when full, by whichever two men were handiest. When a load was ready one man drove to the barn platform and rolled the barrels off alone. On this farm, the average was 289 hours per 1,000 boxes.

Farm 7 hired pickers by paying 8c per field box. The field foreman did practically no picking but helped with the loading. In hauling on this farm, a Ford truck was used most of the time. Two men were required to load and unload, one being on the truck. Even for short distances, the boxes were tied in.

It will be recalled that approximately 336 man hours were required to produce 1,000 boxes of apples up to harvest. With harvesting added, the average requirement was about 694 man hours per 1,000 boxes at the barn.

On some of the farms, picking and hauling were so combined that the horse hours in hauling cannot be used for comparison. Sometimes the horses were taken to the field in the morning and left to eat grass till a load of apples was hauled to the barn. In other cases, the apples were sold in the orchard. In other instances, certain apples were hauled to the co-operative packing plant direct from the orchard.

With the assumed rate of pay the average cost of harvesting apples was $157 per 1,000 boxes; the range was from $127 to $198.

This does not include expense of containers. Some had special picking boxes, and some used regular apple boxes with the expectation of using them later for the market.

When the work of individual men was checked in the field, great differences were apparent. One man on Farm 2 could pick apples about twice as fast as other men. It was noticed that when approaching a tree to pick, he made a decision as to exactly where his ladder was to go. He handled the ladder with considerable dexterity and was usually picking apples with both hands on the way up the ladder. He frequently picked half a bushel before the others had placed their ladders and started picking. No doubt the work of picking might be

speeded up by training and instructing the pickers. On several farms the efficiency of hauling could be increased by making a wagon or truck that could be loaded or unloaded by one man from the ground.

Most of the larger growers were equipped with rollers to get the boxes from the load to the storage.

GRADING AND PACKING

On five farms practically all the apples were graded and packed on the farm, but since there were differences in the type of grading and packing, any comparison is not significant. Farm 2 had a large crop in 1926 which strained the capacity of the warehouse and caused a great deal of extra work in getting apples to the grader. In this case the fruit was stored and then graded and packed by the regular help as needed for the market. In 1928, the operator of this farm built additional space and graded and packed not only the apples of that farm but about 10,000 bushels in addition. In the first two years, 8,023 hours were used in grading and packing 16,301 boxes of apples; this is about 492 hours per 1,000 boxes. In 1928, 6,469 hours were employed in grading and packing 20,800 boxes, or only 311 hours per 1,000 boxes.

Farm 7 graded and packed direct from the field; 7,589 hours were required in grading, packing and piling in storage approximately 24,272 boxes of apples. This is about 312 hours per 1,000 boxes. Farm 9 with a small hand-grader and a very small crew used 1,244 hours in grading and packing the equivalent of 3,250 boxes. This is about 383 hours per 1,000 boxes.

Farm 10 with a small hand-grader used 929 hours in packing 2,030 boxes the first two years and in 1928 with modern power-driven equipment used 238 hours in packing 688 boxes. The difference between 458 hours and 346 hours per 1,000 boxes is not entirely comparable, on account of better grading the last year and difference in quality of apples.

Farm 12 used 721 hours in grading and packing 4,128 boxes, or 174 hours per 1,000 boxes.

On the five farms where apples were packed, the labor in grading and packing apples, and nailing and stacking the boxes averaged 351 hours per 1,000 boxes.

YIELDS

What are the factors that make for good yields of good apples? Farms 2 and 4 work intensively, putting much labor into pruning and

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On one farm an accurate record was kept of the labor cost of packing 2,178 boxes of apples. The fruit was separated into four grades, the first and second being put up in a diagonal count pack each apple individually wrapped as is customary with western box apples; the third was "jumbled" in boxes, and the fourth (ciders) sold in bulk. At actual wages paid, the labor cost spread over the boxed fruit only amounted to 13.3 cents per box. The cost of boxes, paper, use of machinery, light and power increase this to an approximate total of 45 cents per box for the first two grades and about 35 cents for the third grade on which a cheaper box and no paper was used.

moisture control. They received yields of 155 and 130 respectively as compared to an expected normal yield of 100 (Table 27). Did this intensive orchard management make for high yields? Perhaps so, but Farm 8, putting little time on orchard work, secured yields of 188 per cent. of the expected. Farm 9 had average yields of 208 per cent. of normal and did only a moderate amount of work on the orchard. Farm 1 did a rather intensive job of taking care of the trees and got normal yields.

In this study, there is not a sufficient number of farms to draw definite conclusions as to the factors responsible for good yields, but it is barely possible that the site, vigorous stock, and provision for pollination are more important than mere cultural methods. In other words, it may be that with good sites, abundant pollination and healthy vigorous trees to begin with, yields will be high. If this is true, then a combination of high yields and extensive methods would make for low costs. And if site and pollination and stock are very important factors leading to good yields, it is doubtful whether too intensive a system of culture will increase yields materially. Under these conditions, the system needs to be intensive in only those operations that have much to do with quality. This means that spraying would be thorough and intensive. Pruning of young trees for shape would be essential, but beyond opening up the tree somewhat the operation would be unimportant with mature trees.

Suggestion for Future Studies

One of the most important results of a general study such as this is the isolation of important problems for future study.

1. An intensive study of spraying on about 50 farms with a check-up on methods, materials used and the control of disease. Since spraying represents the most difficult orchard management problem, the operation should be studied in more detail on a large number of farms.

2. A long-time study of yields on various sites. This is largely a matter of inventorying about 100 orchards and then securing an annual record of total yields. This should lead to a better understanding of expected yields, the influence of sites on yield and quality, and the influence of different variety combinations on pollination.

3. The cost of grading and packing, a study of the economy of grading and packing under varying situations of price and quality of apples.

4. A minor study of the harvesting of apples.

SUMMARY

1. This study is based on records obtained from 12 New Hampshire fruit farms having a total of about 19,000 trees of various ages. In order to estimate and compare labor requirements, operations were corrected to the basis of 1,000 mature tree units, equivalent to an orchard of about 40 acres in its prime. Requirements were also estimated on the basis of a normal expected yield and of the actual yield.

2. The management problem was found to hinge largely on the organization required for spraying, an operation which requires skilled labor and expensive equipment at very definite short periods.

3. The study did not indicate that intensive detailed pruning beyond the necessary training to get a strong framework with the young tree and to keep the mature tree of reasonable height and free from weak wood was profitable.

4. Under average New Hampshire conditions the sod mulch system of orchard culture was found exceedingly economical.

5. Apple production prior to harvest showed as an enterprise the following operating cost (not including land, trees and overhead):

	Hours				Estimated Cost Including Materials
	Man	Horse	Truck	Tractor	
1,000 mature trees	2,215	817	9	11	$2,128
1,000 boxes normal yield	370	137	1.6	1.9	356
1,000 boxes actual yield	336	124	1.4	1.7	323

The money cost column is based on actual hours at assumed rates plus actual cost of material and estimated cost for use of sprayer.

6. The labor requirement for harvesting was approximately equal to the total prior to harvest. If the apples were graded and packed in boxes, about the same amount of time was again required.

7. Taking into account use of land and appreciation and depreciation of trees, it is estimated that the net operating cost prior to harvest was $514 per 1,000 boxes normal yield or $466 per 1,000 boxes actual yield.

8. Good sites, proper pollination, adequate fertilization and efficient spraying seem essential to securing good yield and high quality. Success in orcharding in New Hampshire depends on the planting of orchards of economic size on good sites and the use of extensive methods in carrying out the essential operations.

NOTE—For a more detailed summary see Figures 1-16 and accompanying captions.